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Monthly Report

March 1987 Number 223

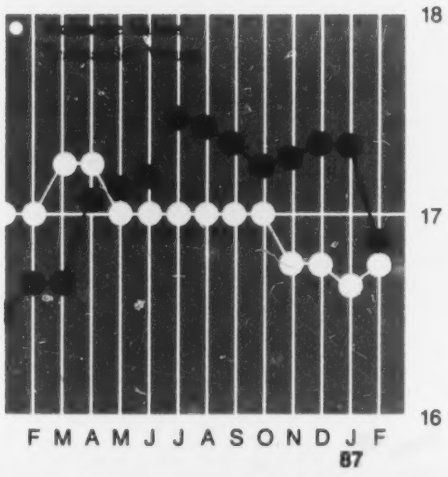
Nuexco Increases Uranium Consumption Forecast.

Potential US Retaliation Against Canadian Upgrading Policy.

US Ban on South African Uranium Imports Examined.

NWPA Update.

Solution Mining of Uranium, Part 2.



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NUEXCO REPORT 223 FIGURES OF THE MONTH (February 28, 1987)	This Month (Report 223)	Last Month (Report 222)	12 Months Ago (Report 211)
Exchange Value[1]	16.75	16.65	17.00
Transaction Value[1]	16.90	17.35	16.70
UF_6 Value[2]	48.00	47.75	48.00
Loan Rate[3]	3%	3%	5%
Conversion Value[4]	1.80	1.80	1.80
Near-Term Uranium Supply[5]	3.4	3.8	2.4
Near-Term Uranium Demand[6]	2.3	2.1	1.0
Near-Term Supply-Demand Ratio	1.5	1.8	2.5
Recent Uranium Sales:			
Number of Transactions[7]	9	4	5
Quantity of Material[8]	2.1	3.6	1.0
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	80	80	80
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	459	457	462
3.0 w/o U_{235}	586	588	592
3.5 w/o U_{235}	719	717	724
4.0 w/o U_{235}	852	849	858

[1]US $ per pound U_3O_8 equivalent.
[2]US $ per kilogram U as UF_6.
[3]Per annum.
[4]US $ per pound U as UF_6.
[5]Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[6]Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[7]Uranium sales only; does not include loans, conversion, or SWU transactions.
[8]Millions of pounds U_3O_8 equivalent.
[9]US $ per SWU.
[10]Effective 10/1/86.
[11]Effective 10/1/85.
[12]Effective 10/1/84.
[13]Effective 10/1/86, for up to 30% of annual requirements.
[14]Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.
[15]US $ per KgU as UF_6, rounded to the nearest $.

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EXECUTIVE SUMMARY
REPORT 223
(All data as of February 28, 1987)

Exchange Value $16.75, up $0.10

The **Exchange Value** is **$16.75** per pound U_3O_8, up $0.10 since last month.

UF_6 Value $48.00, up $0.25

The **UF_6 Value** is **$48.00** per kilogram U as UF_6, up $0.25 since last month.

Transactions

Nine recent natural uranium sales are reported, involving **2.1 million** pounds equivalent U_3O_8 in the near term. All of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. Three of the transactions involved natural UF_6.

Supply-Demand Ratio decreased to 1.5 to 1

Active spot and near-term **uranium supply** amounts to **3.4 million** pounds U_3O_8 equivalent, down 400 thousand pounds since last month. Active spot and near-term **uranium demand** totals **2.3 million** pounds, up 167,000 pounds from last month. The spot and near-term **supply-demand ratio** decreased to **1.5 to 1.**

Transaction Value $16.90, down $0.45

The **Transaction Value** is **$16.90** per pound U_3O_8, **down $0.45** since last month. The calculation includes 12 transactions involving a total of 2.5 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value $1.80, unchanged

The **Conversion Value** is **$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 915 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

SWU Value for delivery within one year: $80, unchanged

The **SWU Value** at .3 tails and for delivery within one year is **$80** per SWU, unchanged since last month. Three secondary market SWU transactions are reported.

* * *

Analysis and Commentary

The 1987 edition of Nuexco's Uranium Market Study and Price Forecast shows a fundamentally different uranium consumption forecast, which significantly affects our forecast of future uranium prices. Improvements in reactor operating results in the past three years have led to an altered forecast of plant capacity factors. Natural uranium consumption is forecast to grow, in the reference case, from 106 million pounds U_3O_8 in 1985 to 145 million pounds in 2000.

United States

The Department of Energy recently sent to Congress a revised draft Mission Plan that officially postpones the date on which DOE expects to be able to receive high-level waste materials into the first repository stipulated in the Nuclear Waste Policy Act of 1982 (NWPA). This article presents an updated account of the recent actions by DOE in implementing the NWPA.

United States

Many nuclear-related legislative and legal issues are being addressed at present or in the near future. A new trade bill could impose a tarriff on uranium from countries requiring mandatory upgrading to UF_6; confusion exists over implementation of the ban on imports of South African uranium; renewal of the Price-Anderson Act is scheduled for debate in Congress; critics question DOE's role in implementing the Nuclear Waste Policy Act.

Raw Materials

Solution mining of uranium has undergone a long process of development since the first projects began in the USA in the early 1960s. Part 2 of this article on solution mining describes current project activity in the USA, and examines regulatory requirements, wellfield procedures, and uranium extraction technology.

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

March 1987 No. 223

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

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To Our Readers

Nuexco is pleased to announce that James G. Munro has joined Nuexco as our representative in Australia. For the 15 years prior to his retirement in December 1985, Jim was associated with Western Mining Corporation Ltd. of Melbourne, where he was Manager, Minerals Marketing Research & Development and was active in uranium marketing, research, and fuel cycle studies. His association with the uranium industry dates back to 1953 when he was a Plant Superintendent at Australia's first commercial uranium project at Rum Jungle in the Northern Territory. Jim is a metallurgical engineer and a graduate of the University of Melbourne. Jim may be reached at:

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of February 28, 1987)

The **Exchange Value** is **$16.75** per pound U_3O_8, up $0.10 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,445,000** pounds U_3O_8 equivalent, down 400 thousand pounds since last month. The corresponding figure for **active demand** is **2,310,000** pounds, up 167,000 pounds. The spot and near-term **supply-demand ratio** decreased to **1.5:1**.

The *Current Market Data* section of this Report lists nine natural uranium sales, totaling 2.1 million pounds U_3O_8 equivalent in the near-term. Three of the transactions involved UF_6. US-origin uranium is commanding a premium (relative to the Exchange Value) of $1.00 per pound U_3O_8 (up $0.15) in the form of concentrates, and $2.50 per kilogram U (unchanged) in the form of UF_6.

The **Transaction Value** is **$16.90** per pound U_3O_8, down $0.45 since last month. The calculation extends over a 3-month period and includes 12 transactions involving 2.5 million pounds equivalent U_3O_8. The large drop in the Transaction Value is a result of the removal from the calculation of transactions that occurred in the last quarter of 1986. These transactions averaged approximately $17.35.

The **UF_6 Value** is **$48.00** per kilogram U in UF_6, up $0.25 since last month. There remains a substantial spread between prices that discretionary UF_6 buyers are willing to pay and those that sellers will accept.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 915 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value rose $0.10 this month to $16.75 per pound U_3O_8. Following the conclusion of several sales at discount prices during February, the availability of low-priced material has subsided. Although much of the demand in both Europe and the USA is still highly discretionary, overall demand has strengthened.

Market activity increased in February, and nine sales of natural uranium, involving more than two million pounds equivalent U_3O_8, are reported. None of the transactions reported during February involved US-origin material. Those sales removed a substantial quantity of demand from the market. Several of the transactions were discretionary purchases motivated by particularly attractive offering terms. Most of the sales reported this month involved European utilities, which are now finding considerable financial advantage in the current weakness of the US dollar, and thus are willing to purchase for inventory on the spot market.

Balancing this reduction in demand, one major buyer entered the market seeking up to one million pounds of U_3O_8 for 1987 delivery, and up to four million pounds in the longer term. Another major buyer was in the process of evaluating bids, but did not conclude its purchase by the end of February.

Demand for Canadian-origin uranium remains weak, but the aggressive selling by Canadian producers that had been evident during the past several months has abated. Recent sales by Canadian producers have temporarily reduced pressure to sell additional material.

The US market is still dominated by the deferrals of procurement activity by utilities that are awaiting the outcome of DOE's appeal in the US producers vs. DOE lawsuit. The appeal has been under consideration by the Tenth Circuit Court of Appeals for nearly six months. US producers are still not active in the spot market and have not lowered prices for their material, as they await a decision that they expect will result in significantly higher prices for US-origin uranium. The producers group has recently petitioned the appeals court to expedite the decision. The producers contend that DOE is facilitating origin swaps, the effect of which is to circumvent the original ruling banning enrichment of imported uranium.

The prevailing uncertainty about future availability and use of non-US-origin material in the USA has resulted in an increase in the premium for US-origin concentrates, to $1.00 per pound U_3O_8 (relative to the Exchange Value). During February, the market for origin and location swaps of non-US for US-origin material has become tighter. Virtually all of the demand for US-origin material is being met through origin swaps, rather than through direct sales by US producers. However, those remaining entities holding US-origin material that might be made available for swaps also are increasingly deferring their decisions to swap their material, while awaiting a resolution of DOE's appeal.

Consequently, not only are swaps becoming less available and more costly, public scrutiny by US government agencies and storage facilities, regardless of their degree of legal authority over swap transactions, has effectively increased the complexity and risk involved in swapping origins. In particular, the problems of swapping origins between lots of

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uranium of different chemical forms have created a situation in which swapped US-origin UF_6 is more readily available than US-origin U_3O_8. The expressed preference by one of the major new buyers for US-origin uranium also has served to increase the premium value of US-origin.

The UF_6 Value increased this month, to $48.00 per kgU as UF_6. Demand for UF_6 appears somewhat stronger than demand for concentrates, with several buyers in the market for substantial quantities. Potential uranium buyers that are not committed to conversion contracts tend to prefer to purchase in the form of UF_6, therefore the premium for US-origin UF_6 did not increase.

* * *

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported, and the market for loans continues to be essentially dormant. In the event that firm demand for loans emerged, ample supply would likely become available at reasonable loan rates.

* * *

The Conversion Value is unchanged since last month at $1.80. The secondary market for conversion services shows slightly increased activity this month, and one conversion transaction is reported. In Europe, secondary market conversion remains largely uncompetitive, as the weak dollar has made such services more expensive than in the USA or in Canada.

ENRICHED URANIUM AND SWUS

The SWU value is unchanged since last month, remaining at $80.00 per SWU. Three SWU transactions are reported in the *Current Market Data* section of the Report, totaling over 400 thousand SWUs. Included in this total is a small quantity of Soviet origin. Spot sales of Soviet-origin SWUs have increased dramatically over the past several months. However, to conclude sales of Soviet-origin SWUs, sellers have been obliged to offer substantial discounts in order to overcome buyers' reluctance.

The presence of discounted Soviet-origin SWUs has widened the spread of SWU prices in the current market, which tend to reflect origin, quantity, and specifications for enriched product. As with uranium, origin has become an increasingly important consideration in SWU prices. The presence in the market of several potential buyers of substantial quantities of SWUs was balanced by greater availability of SWUs for sale, resulting in little price pressure in either direction. As of the end of the month, two secondary market buyers continued to evaluate offers for large quantities of non-Soviet SWUs.

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CURRENT MARKET DATA

February 28, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.75**/lb. U_3O_8	3,445	2,310
UF_6 VALUE	**$48.00**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	915	1,000
SWU VALUE 0.3 tails assay; delivery within one year	**$80**/SWU		
LOAN RATE	**3%**/annum	0	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**16.90**	2.5	12	3

[1]Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Feb 28, 1987)	Last Month (Jan 31, 1987)	12 Months Ago (Feb 28, 1986)	This Month (Feb 28, 1987)	Last Month (Jan 31, 1987)	12 Months Ago (Feb 28, 1986)
Australia (dollar)	24.83	25.16	23.97	64.54	65.41	62.31
Belgium (comm. franc)	632.06	615.98	771.68	1,643	1,601	2,006
Canada (dollar)	22.32	22.33	23.98	58.01	58.05	62.35
EEC (ecu)	14.79	14.42	17.39	38.46	37.49	45.21
Finland (markka)	75.86	74.83	86.03	197.22	194.54	223.66
France (franc)	101.70	99.28	116.20	264.40	258.12	302.09
FRG (mark)	30.55	29.75	37.89	79.43	77.35	98.50
Italy (lira)	21,691	21,213	25,668	56,392	55,149	66,731
Japan (yen)	2,564	2,535	3,082	6,666	6,590	8,012
Netherlands (guilder)	34.52	33.57	42.67	89.75	87.27	110.93
South Africa (rand)	34.54	33.98	33.73	89.79	88.34	87.69
Spain (peseta)	2,145	2,122	2,380	5,576	5,517	6,187
Sweden (krona)	107.93	107.28	121.69	280.58	278.91	316.37
Switzerland (franc)	25.73	25.02	32.00	66.89	65.03	83.20
UK (pound)	10.87	10.83	11.58	28.25	28.14	30.11
US (dollar)	16.75	16.65	17.00	43.55	43.29	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Feb 28, 1987)	Last Month (Jan 31, 1987)	12 Months Ago (Feb 28, 1986)	This Month (Feb 28,1987)	Last Month (Jan 31, 1987)	12 Months Ago (Feb 28, 1986)
Australia (dollar)	25.05	26.22	23.54	65.12	68.16	61.21
Belgium (comm. franc)	637.74	641.88	758.06	1,658	1,669	1,971
Canada (dollar)	22.52	23.27	23.56	58.53	60.49	61.25
EEC (ecu)	14.93	15.03	17.08	38.80	39.06	44.41
Finland (markka)	76.54	77.98	84.51	198.99	202.72	219.72
France (franc)	102.61	103.46	114.15	266.77	268.97	296 76
FRG (mark)	30.83	31.00	37.22	80.15	80.60	96.76
Italy (lira)	21,886	22,105	25,215	56,897	57,476	65,554
Japan (yen)	2,587	2,642	3,028	6,725	6,868	7,871
Netherlands (guilder)	34.83	34.98	41.92	90.55	90.94	108.98
South Africa (rand)	34.85	35.41	33.13	90.59	92.05	86.14
Spain (peseta)	2,164	2,211	2,338	5,626	5,749	6,078
Sweden (krona)	108.89	111.79	119.54	283.09	290.63	310.78
Switzerland (franc)	25.96	26.07	31.44	67.49	67.77	81.73
UK (pound)	10.96	11.28	11.38	28.50	29.33	29.58
US (dollar)	16.90	17.35	16.70	43.94	45.11	43.42

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on Feb. 27, 1987.

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CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Feb 28, 1987)	Last Month (Jan 31, 1987)	12 Months Ago (Feb 28, 1986)	This Month (Feb 28, 1987)	Last Month (Jan 31, 1987)	12 Months Ago (Feb 28, 1986)
Australia (dollar)	2.67	2.72	2.54	5.88	6.00	5.59
Belgium (comm. franc)	67.92	66.59	81.71	149.75	146.81	180.13
Canada (dollar)	2.40	2.41	2.54	5.29	5.32	5.60
EEC (ecu)	1.59	1.56	1.84	3.50	3.44	4.06
Finland (markka)	8.15	8.09	9.11	17.97	17.83	20.08
France (franc)	10.93	10.73	12.30	24.09	23.66	27.12
FRG (mark)	3.28	3.22	4.01	7.24	7.09	8.84
Italy (lira)	2,331	2,293	2,718	5,139	5,056	5,992
Japan (yen)	275.52	274.06	326.32	607.43	604.19	719.42
Netherlands (guilder)	3.71	3.63	4.52	8.18	8.00	9.96
South Africa (rand)	3.71	3.67	3.57	8.18	8.10	7.87
Spain (peseta)	230.50	229.42	252.00	508.17	505.78	555.55
Sweden (krona)	11.60	11.60	12.88	25.57	25.57	28.41
Switzerland (franc)	2.76	2.70	3.39	6.10	5.96	7.47
UK (pound)	1.17	1.17	1.23	2.57	2.58	2.70
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU Value delivery within one year (Feb 28, 1987)	UF_6 Value per kg.U in UF_6 This Month (Feb 28, 1987)	UF_6 Value per kg.U in UF_6 Last Month (Jan 31, 1987)
Australia (dollar)	118.57	71.14	72.15
Belgium (comm. franc)	3,019	1,811	1,767
Canada (dollar)	106.58	63.94	64.03
EEC (ecu)	70.66	42.39	41.35
Finland (markka)	362.32	217.39	214.60
France (franc)	485.73	291.43	284.73
FRG (mark)	145.93	87.55	85.32
Italy (lira)	103,600	62,160	60,836
Japan (yen)	12,246	7,347	7,270
Netherlands (guilder)	164.88	98.92	96.27
South Africa (rand)	164.95	98.96	97.44
Spain (peseta)	10,245	6,147	6,086
Sweden (krona)	515.46	309.27	307.66
Switzerland (franc)	122.89	73.73	71.73
UK (pound)	51.90	31.13	31.04
US (dollar)	80.00	48.00	47.75

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on Feb. 27, 1987.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3970	1987	101-300	100	Utility	Trader	
3966	1987	101-300	98	Trader	Utility	UF_6
3964	1987	101-300	104	Producer	Trader	
3962	1987	301-600	102	Producer	Trader	
3961	1987	601-1000	99	Trader	Utility	
3960	1987	less than 50	100	Utility	Trader	
3959	1987	less than 50	109	Trader	Utility	UF_6
3948	1987	101-300	94	Utility	R[5]	
3939	1987	101-300	103	Trader	Utility	UF_6

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.
[3]Price is not normalized to 0.20% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

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Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3955	1988	101-300	101	Trader	Utility	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
3967	1988	50-100	106	Trader	Utility	R[5]	
3968	1988	less than 50	90	Trader	Utility	USSR	
3969	1987-88	301-600	101	Trader	Utility	R[5]	

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.
[3]Price is not normalized to 0.20% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

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CURRENT MARKET DATA

URANIUM SUPPLY
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2335*	420	—	
2740*	250	—	
2893A*	720	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2989	40	—	
3023	500	500	UF_6
3121	500	—	
2263	—	400 per year	1989 on
2781	—	750 per year	1988-95
2996	—	500 per year	1988-90
3129	500	500	
3171	—	200 per year	1988-92
TOTAL:	3,445		
INACTIVE			
2297	100	100 per year	1988-89
2389	75	75 per year	1988-90
2764	260	—	UF_6
3166	25	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981*	—	600 per year	1988-91
3128*	—	100	1989
TOTAL:	510		

*New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2885B, 2975, 2990, 3194.

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URANIUM DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2878A*	60	—	U_3O_8 or UF_6
2890*	175	—	
2984*	330	—	U_3O_8 and UF_6
2991	105	—	UF_6
3009	590	—	UF_6
3120*	1,000	1,000 per year	1988-91
3192	50	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500	1989 on
2985	—	675 per year	1992 on
3147	—	200	1988-92
3193*	—	700 per year	1989 on
TOTAL:	2,310		
INACTIVE			
2760	750	750 per year	1988-90
2798*	50	—	
2911*	65		UF_6
2956	350	350	U_3O_8 or UF_6
TOTAL:	1,215		

*New or revised since last month.

[1]Measured from the date of this Report.

[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2995, 3017, 3097, 3158.

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CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
2859*	750	750	
2988*	165	—	
TOTAL:	915		
Available for Sale: INACTIVE			
3165*	330	—	
TOTAL:	330		
Inquiries to Purchase: ACTIVE			
3120*	1,000	700	1988-89
TOTAL:	1,000		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

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CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2920	2,000	—	
TOTAL:	4,500		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

No inquiries to borrow are reported this month.

SWU SUPPLY AND DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2571*	55	—	1987
2969	200	—	1987
3156	70	—	1987
3162*	50	—	1987
3213*	205	—	1987
TOTAL:	580		
Inquiries to Purchase:			
ACTIVE			
2878	65	—	1987
2999	150	—	1987
3009	200	—	1987
3043*	10	—	1987
TOTAL:	425		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: None.

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ANALYSIS AND COMMENTARY

WORLD URANIUM CONSUMPTION FORECAST, 1987-2000

This article summarizes Nuexco's revised uranium consumption forecast for the remainder of this century. A more detailed analysis is presented in Nuexco's Uranium Market Study and Price Forecast.

Introduction

The 1987 edition of Nuexco's Uranium Market Study and Price Forecast shows a fundamentally different uranium consumption forecast, which significantly affects our forecast of future uranium prices. The changes in Nuexco's outlook for consumption have resulted primarily from an altered forecast of plant capacity factors in the period, brought about by unanticipated improvements in reactor operating results in the past three years.

The Uranium Institute recently published its report entitled "The Uranium Market 1986 – 2000", which, among other data, contains the Institute's forecast of nuclear electric generating capacity and the corresponding uranium requirements. The Institute's generating capacity forecast is greater than Nuexco's, but its uranium requirements forecast is lower than Nuexco's. Nuexco has compared the forecasts in order to determine the reasons for the differences. The following analysis illustrates Nuexco's methodology, and examines some of the differences between the two forecasts of uranium consumption.

Nuexco Methodology

The term "consumption", as used by Nuexco, means the amount of natural uranium, in the form of ore concentrates, needed to be delivered to a conversion plant (converting ore concentrates to UF_6) in order to begin preparation of fuel assemblies, on a normal lead time prior to:

— the commercial operation date (COD) of a given reactor if for an initial core, or

— the periodic refueling date if for reload fuel. Nuexco has used a lead time of 24 months prior to COD for the initial core, and 18 months prior to refueling for reloads. Nuexco treats the uranium as being consumed when it enters the chain of fuel preparation operations. Thus, for a reactor starting commercial operation in 1990, the natural uranium for the initial core loading is classified as being consumed in 1988. The amount of uranium is expressed in terms of pounds U_3O_8 equivalent.

Natural uranium consumption is forecast to grow in the reference case from 106 million pounds U_3O_8 in 1985 to 145 million pounds in 2000, an increase of 37 percent over 15 years, corresponding to an average annual compound growth rate of 2.1 percent. In Nuexco's previous Uranium Market Study and Price Forecast (released in January 1985), the reference case consumption forecast for 2000 was 128.4 million pounds. The difference is largely due to the use of higher plant capacity factors in the current forecast. The consumption calculations are based on an average enriching plant tails assay of 0.25 weight-percent (w/o) U_{235} throughout the study period.

Figure 1 shows Nuexco's uranium consumption forecast for the reference growth case. Figure 2 shows a comparison of the reference, low and high growth cases. Tables 1, 2, and 3 list the forecast uranium consumption by region by year for the reference, low growth and high growth cases. In the USA, uranium consumption averages 39.7 million pounds annually during the study period. However, consumption continues to increase in the other three geographic regions in the study. The reference case average growth rate in uranium consumption, for the period 1986 through 2000, for each region is as follows:

	Average Growth Rate, 1986 — 2000	
Region	Thousands of Pounds U_3O_8 per Year	Compound Growth Rate, Percent per Year
USA	291	0.8
Europe	1,017	1.8
Far East	1,010	4.8
Other	223	2.8
WORLD	2,541	2.1

The Far East shows the largest growth rate, in percent per year, of the four regions studied. These forecasts of uranium consumption utilize Nuexco's latest computational procedures and data, as further described below.

Principal Controlling Variables Affecting Consumption

Nuexco examines five principal variables affecting uranium consumption. They are listed as follows, and each are described more fully in succeeding paragraphs.

1. Nuclear electric generating capacity in operation, and annual additions.

2. Nuclear plant characteristics, including projected operating life, core loading, and thermal efficiency.

3. Plant operating characteristics, such as the capacity factor and the cycle length between refuelings.

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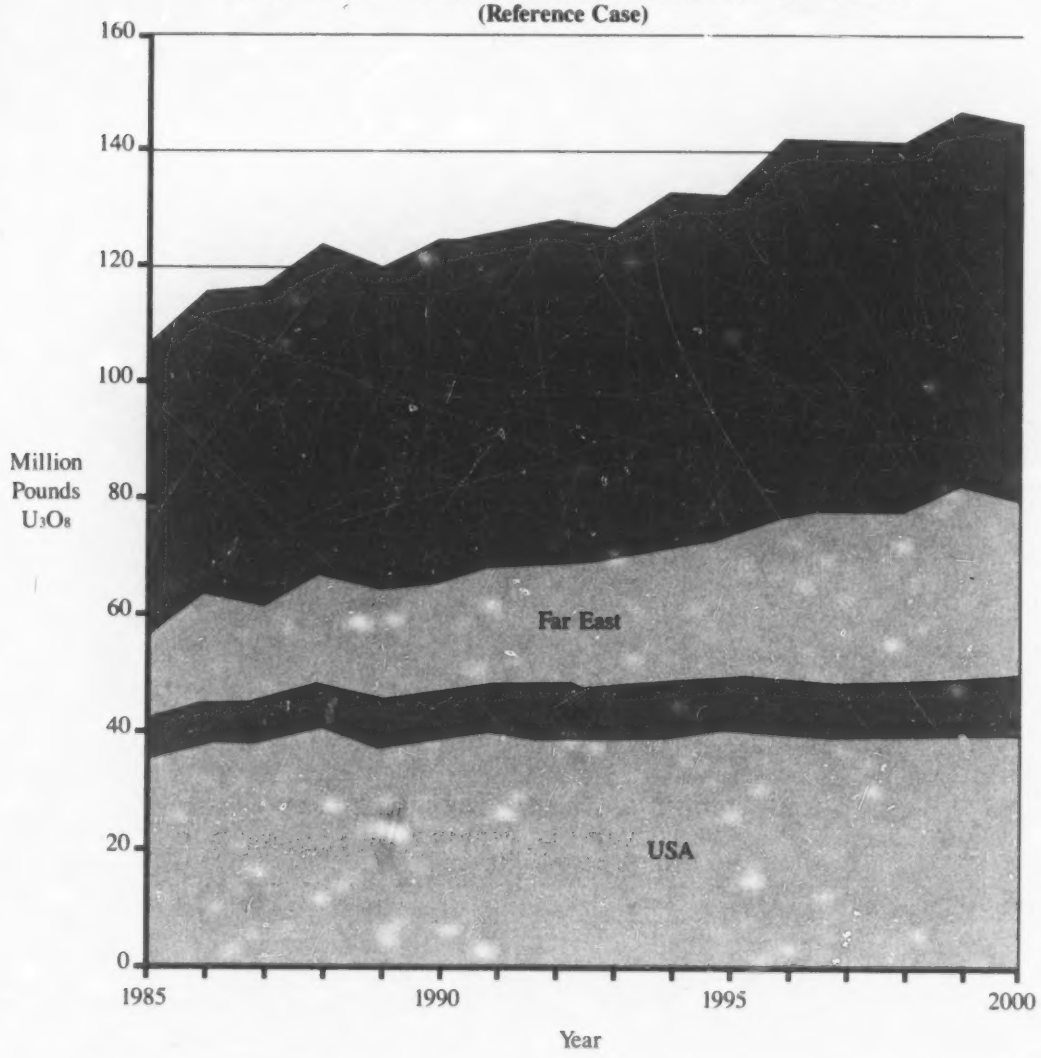
Figure 1

FORECAST OF WORLD URANIUM CONSUMPTION BY REGION
(Reference Case)



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ANALYSIS & COMMENTARY

TABLE 1A

WORLD URANIUM CONSUMPTION FORECAST[1]
Reference Case
(Millions of Pounds U_3O_8)

	1986	1987	1988	1989	1990	1991	1992	1993
United States	38.3	38.9	41.3	38.0	39.2	40.3	39.0	39.4
Europe[2]	51.2	54.0	56.0	54.2	58.3	56.4	58.8	55.8
Far East[3]	19.2	16.1	19.4	19.4	18.7	20.7	20.7	22.5
Other Nations[4]	6.8	7.1	7.0	7.8	7.9	7.9	9.4	8.4
TOTAL[5]	115	116	124	119	124	125	128	126

TABLE 2A

WORLD URANIUM CONSUMPTION FORECAST[1]
Low Case
(Millions of Pounds U_3O_8)

	1986	1987	1988	1989	1990	1991	1992	1993
United States	37.2	39.0	35.9	37.4	39.4	37.4	37.7	37.7
Europe[2]	48.5	50.1	49.8	52.7	54.1	52.7	54.4	55.6
Far East[3]	18.8	15.6	16.9	18.8	18.8	17.5	22.0	19.8
Other Nations[4]	6.5	6.4	6.6	6.9	6.9	6.8	7.9	7.8
TOTAL[5]	111	111	109	116	119	114	122	121

TABLE 3A

WORLD URANIUM CONSUMPTION FORECAST[1]
High Case
(Millions of Pounds U_3O_8)

	1986	1987	1988	1989	1990	1991	1992	1993
United States	39.2	39.5	39.0	40.5	39.2	39.5	39.4	42.0
Europe[2]	51.3	56.0	57.3	57.0	57.6	58.1	58.6	61.7
Far East[3]	16.8	19.2	17.2	18.7	21.9	20.3	22.3	25.3
Other Nations[4]	7.6	7.5	8.1	8.0	9.4	9.2	8.7	9.1
TOTAL[5]	115	122	122	124	128	127	129	138

[1]Consumption is based on computed quantities of U_3O_8 used to fabricate fuel for loading and reloading reactors operating, under construction, on order or forecasted as of 12/31/86. Compiled and computed on a reactor-by-reactor basis; quantities for each reactor are based on specific core characteristics, 0.25% enriching tails assay, no recycling, 24-month lead time for first cores and 18-month lead time for reloads.

[2]Austria, Belgium, Finland (Two Swedish-supplied plants), France, Germany (FRG), Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Yugoslavia.

[3]China (PRC), Japan, South Korea, Philippines, Taiwan.

[4]Argentina, Brazil, Canada, Egypt, India, Iran, Iraq, Israel, Libya, Mexico, Pakistan, South Africa and Turkey.

[5]Includes only those nations that participate in the commercial uranium market. Nations which are excluded are Bulgaria, Cuba, Czechoslovakia, Germany (GDR), Finland (two USSR-supplied plants), Hungary, Poland, Rumania, and the USSR. Columns may not add, due to rounding.

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TABLE 1B

WORLD URANIUM CONSUMPTION FORECAST[1]
Reference Case
(Millions of Pounds U_3O_8)

	1994	1995	1996	1997	1998	1999	2000
United States	39.4	40.7	40.5	39.6	40.1	40.1	40.1
Europe[2]	60.8	58.3	64.4	62.1	62.5	63.7	64.5
Far East[3]	22.7	24.2	27.7	30.0	29.3	32.9	30.2
Other Nations[4]	9.8	8.9	9.0	9.1	9.3	9.7	9.8
TOTAL[5]	133	132	142	141	141	146	145

TABLE 2B

WORLD URANIUM CONSUMPTION FORECAST[1]
Low Case
(Millions of Pounds U_3O_8)

	1994	1995	1996	1997	1998	1999	2000
United States	37.7	37.7	37.6	37.5	37.5	37.5	37.5
Europe[2]	56.0	56.1	57.3	55.8	59.1	58.2	58.7
Far East[3]	21.2	22.6	22.9	24.9	23.8	25.7	29.8
Other Nations[4]	8.6	8.3	9.6	8.2	8.8	8.7	8.6
TOTAL[5]	123	125	127	126	129	130	135

TABLE 3B

WORLD URANIUM CONSUMPTION FORECAST[1]
High Case
(Millions of Pounds U_3O_8)

	1994	1995	1996	1997	1998	1999	2000
United States	41.9	40.3	41.1	41.0	41.0	41.0	41.0
Europe[2]	60.7	65.8	64.1	66.3	66.7	65.4	70.0
Far East[3]	23.8	29.3	31.3	32.8	34.8	34.6	33.5
Other Nations[4]	8.9	9.2	9.2	10.1	9.4	10.1	10.3
TOTAL[5]	185	145	146	150	152	151	155

[1]Consumption is based on computed quantities of U_3O_8 used to fabricate fuel for loading and reloading reactors operating, under construction, on order or forecasted as of 12/31/86. Compiled and computed on a reactor-by-reactor basis; quantities for each reactor are based on specific core characteristics, 0.25% enriching tails assay, no recycling, 24-month lead time for first cores and 18-month lead time for reloads.

[2]Austria, Belgium, Finland (Two Swedish-supplied plants), France, Germany (FRG), Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Yugoslavia.

[3]China (PRC), Japan, South Korea, Philippines, Taiwan.

[4]Argentina, Brazil, Canada, Egypt, India, Iran, Iraq, Israel, Libya, Mexico, Pakistan, South Africa and Turkey.

[5]Includes only those nations that participate in the commercial uranium market. Nations which are excluded are Bulgaria, Cuba, Czechoslovakia, Germany (GDR), Finland (two USSR-supplied plants), Hungary, Poland, Rumania, and the USSR. Columns may not add, due to rounding.

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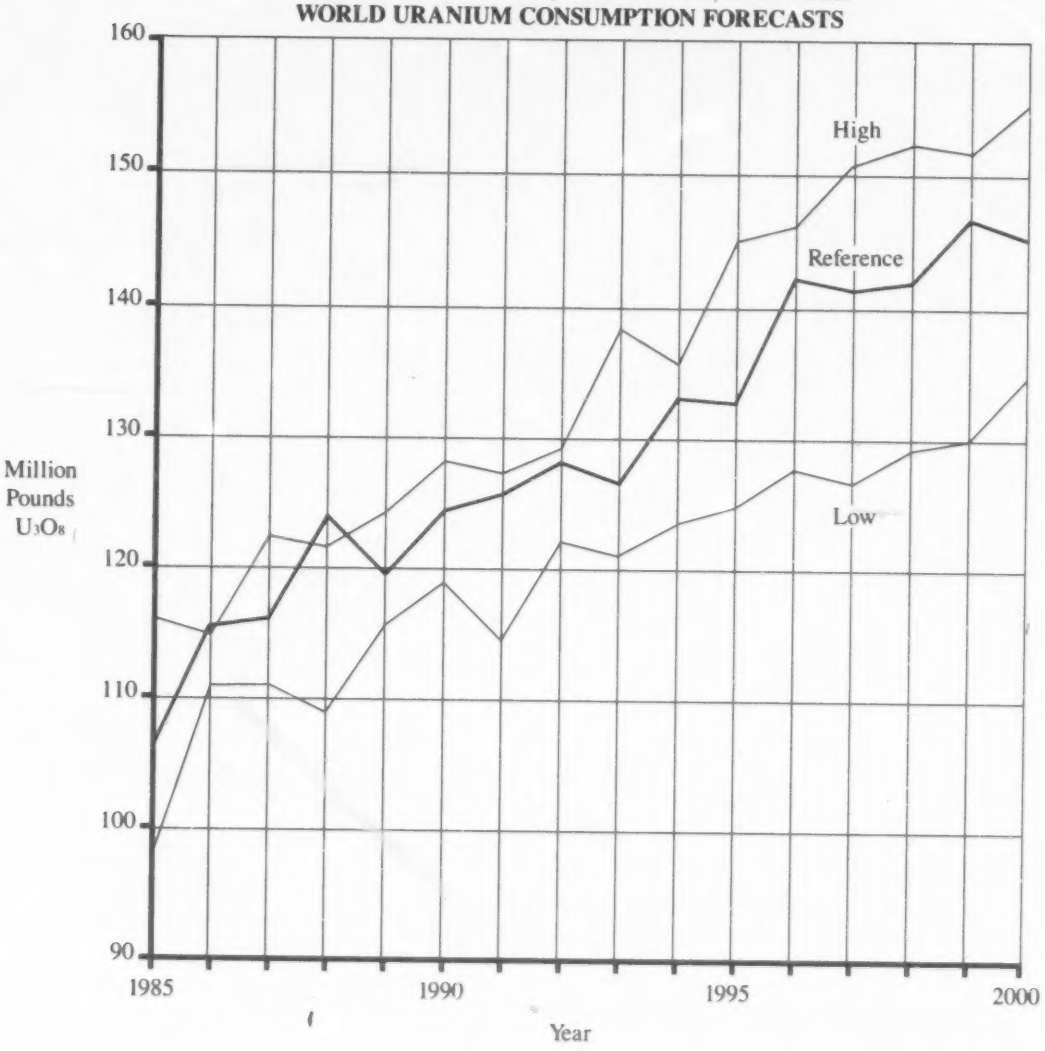
ANALYSIS & COMMENTARY

Figure 2

COMPARISON OF LOW, REFERENCE, AND HIGH WORLD URANIUM CONSUMPTION FORECASTS



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4. Nuclear fuel characteristics, such as fuel design, initial core enrichment, and reload fuel enrichment.

5. Fuel cycle characteristics, including the enrichment tails assay, the recycle of uranium and plutonium, fuel preparation lead times, and processing losses.

1. *Electric Generating Capacity and Annual Additions.* The amount of uranium needed for reload fuel varies with installed capacity, and the amount needed for initial core loadings varies with additions to generating capacity.

2. *Plant Design Characteristics.*

— Plant Operating Life – Nuexco normally uses a 35-year operating life (from commercial operation date) for all plants in the forecast, unless a different lifetime is scheduled. Expected retirements are deducted from new plant additions in arriving at net installed capacity.

— Core Loading – Nuexco uses core loadings characteristic of each type of plant. The specific power (MWe/MTU) appropriate to each type of reactor is used in this calculation, so as to relate the size of the core loading to the reactor power rating.

— Thermal Efficiency – Nuexco uses net thermal efficiencies (MWe/MWt) characteristic of each reactor type. These values are typical of each of the stated classes of reactors.

Reactor Type	Net Thermal Efficiency (percent)
PWR	32
BWR	32
HWR	30
GCR	36
AGR	41

3. *Plant Operating Characteristics.*

— Capacity factor – This is the ratio of actual electric production to theoretical maximum production if the plant ran at full power 100 percent of the time. In some countries, this is called "plant factor" or "load factor". This variable is extremely important in projecting uranium consumption. In the latest analysis, Nuexco has examined capacity factor data much more rigorously than in the past. Examination of nuclear plant capacity factor data worldwide has led Nuexco to utilize capacity factor values that vary by country and reactor type. BWR and PWR reactors comprise the bulk of the generating capacity, but the other reactor types must also be addressed. As of the end of 1985, world installed nuclear electric generating capacity was distributed by reactor type as follows:

Reactor Type	Percent of Total
PWR	59
BWR	29
HWR	6
GCR	4
AGR	2
	100

Nuexco has used plant-by-plant capacity factor data published by *Nuclear Engineering International*[1], in the course of developing a set of capacity factor assumptions. The capacity factors for the nuclear units by country by reactor type were compiled for 1983, 1984, and 1985. These data were then processed to give averages by reactor type by country. The three-year average was viewed as being representative of the present status of capacity factor values for that reactor type in that country. Next, in order to allow for future improvement over the study period, the current three-year average capacity factors were increased by 25 percent of the difference between the current factor and either 85 or 90 percent. The value of 85 percent is viewed as the maximum sustained average annual capacity factor that might be expected from reactors that shut down for refueling, and 90 percent is viewed as the maximum for reactors with on-line refueling. The 25-percent factor is intended to represent the practical capacity factor increase potential over the near future. This methodology yields small additional improvement in capacity factor for those countries or reactor types presently experiencing high capacity factors, and a relatively large expected improvement for countries or reactor types presently experiencing low capacity factors. The resulting capacity factor values, listed by country by reactor type, are listed in Table 4.

There are a number of instances where a given reactor type is either not presently in operation in a given country, or there have been less than three years of operating experience, yet Nuexco still is forecasting the operation of that reactor in that country in the future. For these cases, the capacity factor of that reactor type in that country is assumed to be the *average value* of the projected capacity factor of the same reactor type in countries where there *is* operating data for that reactor. These cases can be identified in the table by the omission of the three-year historical value. These average values are then used in the calculation of uranium consumption. On a weighted basis of generating capacity as of the end of 1985, these individual capacity factors yield a world weighted average capacity factor of 71 percent. The capacity factors used by Nuexco in this forecast are substantially greater than those

[1]ISSN #0029-5507.

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used in the 1985 Market Study, thus causing a substantial increase in projected uranium requirements.

Figure 3 shows the cumulative frequency distribution of reactor capacity factors for the world for 1985, using data from Table 5. There are 253 reactors in this sample. Half of the reactors experienced a capacity factor in 1985 of 72.8 percent or greater. However, due to the skewed distribution, the average capacity factor in 1985 is 67.0 percent. During the past three years, the average world reactor capacity factor has been trending upward as illustrated below.

Year	Average Capacity Factor (Percent)
1983	62.1
1984	64.9
1985	67.0
Three Year Average	64.7

— Cycle Length – There is a substantial trend toward longer operating cycles between refuelings. This is usually accompanied by the use of greater fuel burnups. The incentive for longer operating cycles is that minimizing downtime for refuelings leads to better capacity factors. Increases in cycle length generally result in a higher fuel cost, which is usually more than offset by a reduction in cost of replacement energy when the plant is down for refueling. Most US reactors are expected to be on 18 month or longer cycles by the early 1990s. Conversion to longer cycles, accompanied by the use of greater fuel burnup, results in the uranium consumption per unit of energy production remaining approximately constant. However, there is an increase in the inventory of equivalent natural uranium in the reactor, and this is reflected in an increase in uranium consumption as the transition occurs.

The Nuexco uranium consumption calculations are based on cycle lengths planned for each reactor. However, the consumption results are presented on an annualized basis, thereby smoothing the consumption projection curves.

Table 4

CAPACITY FACTORS USED IN CONSUMPTION CALCULATIONS

Country	Reactor Type	Average Capacity Factor over the past 3 Years[1] (Percent)	Future Improvement[2] (Percent)	Projected Capacity Factor[2] (Percent)
Argentina	HWR	63.9	6.5	70
Belgium	PWR	81.7	0.8	83
Brazil	PWR	30.1	13.7	44
Canada	HWR	72.1	4.5	77
Egypt	PWR	—	—	68
Finland	BWR	87.8	0	85
France	GCR	39.6	12.6	52
	PWR	71.6	3.4	75
	FBR	60.7	6.1	67
FR Germany	BWR	73.2	3.0	76
	PWR	81.9	0.8	83
	HWR	—	—	70
	AGR	—	—	63
	FBR	—	—	52

[1]Source: *Nuclear Engineering International.*
[2]Nuexco data.

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Table 4 (continued)

CAPACITY FACTORS USED IN CONSUMPTION CALCULATIONS

Country	Reactor Type	Average Capacity Factor over the past 3 Years[1] (Percent)	Future Improvement[2] (Percent)	Projected Capacity Factor[2] (Percent)
India	BWR	51.6	8.4	60
	HWR	32.9	14.3	47
Italy	BWR	57.6	6.8	64
	GCR	64.4	6.4	71
	PWR	43.1	10.5	54
	HWR			70
Japan	BWR	70.8	3.6	74
	GCR	64.1	6.4	71
	HWR	65.7	6.1	72
	PWR	72.2	3.2	75
	FBR	—	—	52
Mexico	BWR	—	—	73
Netherlands	PWR	79.2	1.4	81
Pakistan	PWR	—	—	68
	HWR	—	—	70
South Africa	PWR	49.8	8.8	59
South Korea	HWR	80.8	2.3	83
	PWR	64.4	5.2	70
Spain	BWR	65.2	5.0	70
	GCR	68.6	5.4	74
	PWR	49.0	9.0	58
Sweden	BWR	76.1	2.2	78
	PWR	59.2	6.4	66
Switzerland	BWR	88.7	0	85
	PWR	87.4	0	85
Taiwan	BWR	73.4	2.9	76
	PWR	39.1	11.5	51
Turkey	HWR	—	—	70
United Kingdom	AGR	54.1	9.0	63
	GCR	64.0	6.5	71
	FBR	21.0	16.0	37
	HWR	—	—	70
	PWR	—	—	68
USA	BWR	52.8	8.0	61
	Graphite	45.2	10.0	55
	GCR	10.3	18.7	29
	PWR	61.3	5.9	67
Yugoslavia	PWR	71.0	3.5	74

[1]Source: *Nuclear Engineering International.*
[2]Nuexco data.

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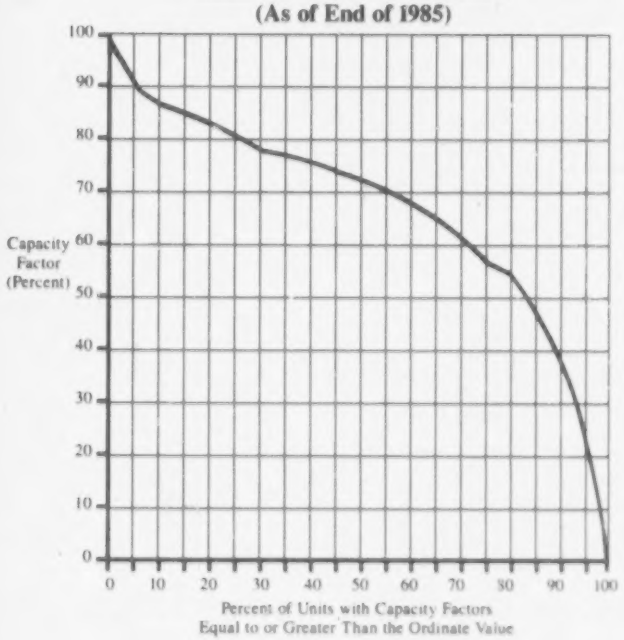
Figure 3

NUCLEAR PLANT CAPACITY FACTORS
CUMULATIVE FREQUENCY DISTRIBUTION
Based on 253 Units Worldwide
(As of End of 1985)



4. *Fuel Characteristics.*

— Fuel Design – Improvements continue to be made in the design of fuel assemblies, many of which improve the utilization of uranium. These will undoubtedly continue, but at a diminishing rate.

— Initial Core Enrichment – In most reactors, the owner may select low, medium or high enrichment initial core designs. This choice affects the length of the first operating cycle and the size and enrichment of the first several reloads. The Nuexco data are weighted toward use of a mid-range enrichment.

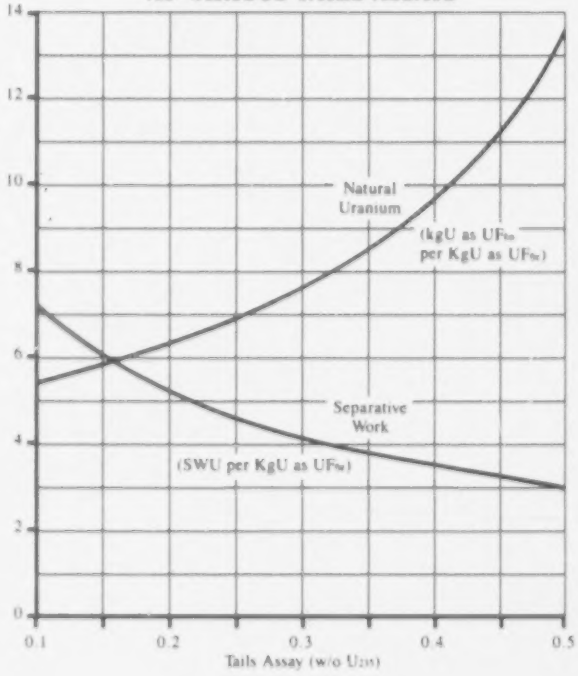
— Reload Fuel Enrichment – As previously noted, there is a tendency toward higher burnups, together with extended duration fuel cycles. The net change in natural uranium consumption between low burnup/short cycles and high burnup/long cycles is small.

5. *Fuel Cycle Characteristics.*

— Enrichment Tails Assay – The companies providing enrichment services offer the customer various choices in specifying the tails assay to be used in the transaction. The tails assay affects the relative amounts of separative work versus natural uranium feed required to produce a given amount of enriched uranium. Consider a product enrichment of 3.4 w/o U_{235} in total uranium. For a tails assay of 0.2 w/o U_{235}, 5.191 kg of separative work units (SWU) and 6.262 kgU as natural UF_6 are required to produce one kilogram of product, whereas at a tails assay of 0.3 w/o, 4.154 kg of SWU and 7.543 kgU as UF_6 are required. Figure 4 shows the uranium and SWU required to produce one kilogram of enriched uranium at a product enrichment of 3.4 w/o, over a tails assay range from 0.1 w/o to 0.5 w/o.

Figure 4

NATURAL URANIUM AND SWU REQUIRED TO PRODUCE ONE KILOGRAM OF 3.4% EUP AT VARIOUS TAILS ASSAYS



Providing enrichment customers the right to set the tails assay enables the customer to optimize its costs of enriched uranium, depending on SWU and uranium costs. DOE agreed to waive its announced surcharge on the use of tails assays other than the standard value (currently 0.2 w/o) for enrichment customers that take 100 percent of their SWU requirements from DOE. Figure 5 indicates the tails assays

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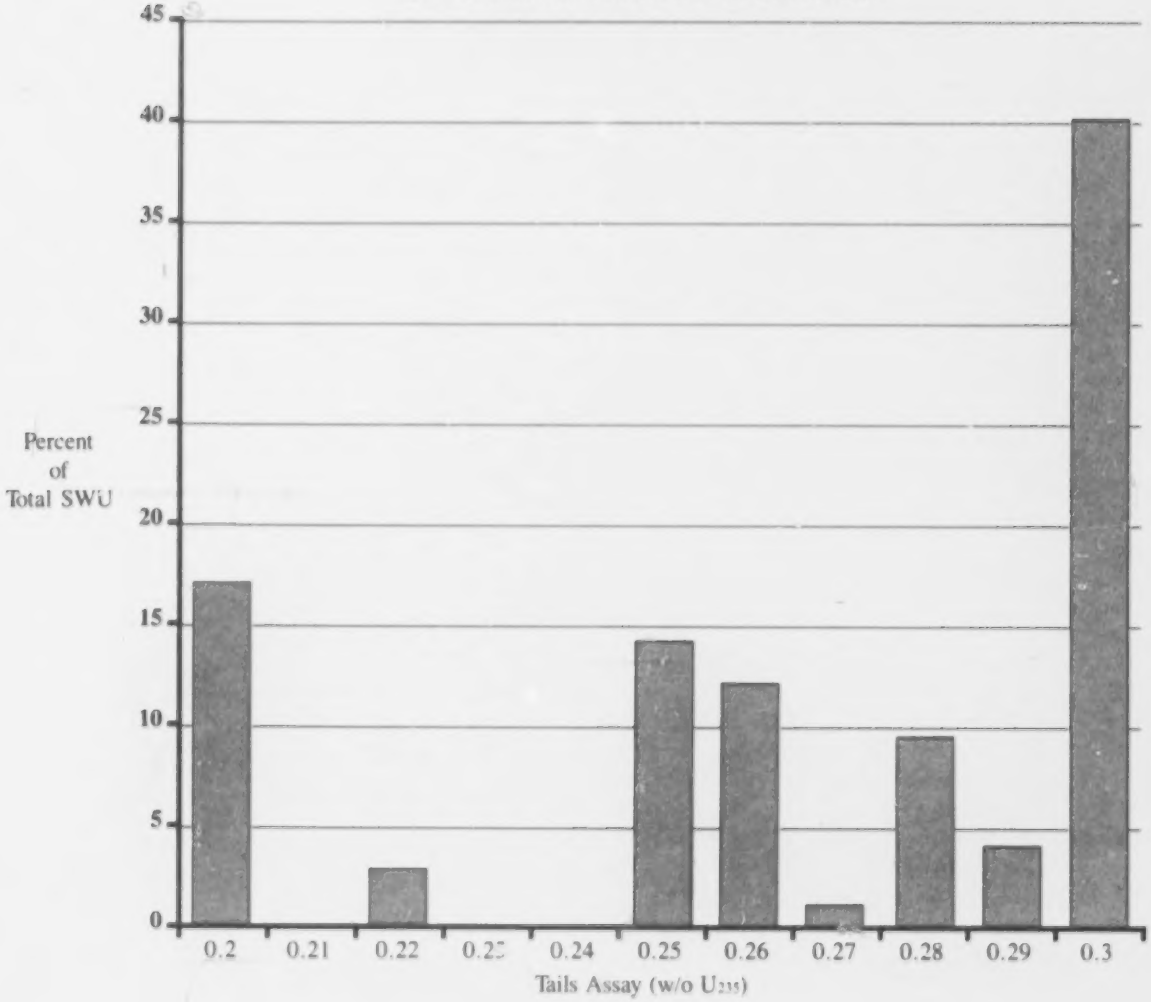
Figure 5

ENRICHMENT TAILS ASSAY SPECIFIED BY DOE CUSTOMERS FOR FY87 DELIVERIES



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currently utilized by DOE customers in FY1987. The ordinate is the proportion of SWUs sold at the stated transaction tails assay to all SWUs sold at all tails assays, expressed as a percentage. The weighted average tails assay in that year is 0.27 w/o. Note that the most frequent assay selected is 0.3 w/o.

In the above example, the use of 0.3 w/o tails versus 0.2 w/o reduces uranium consumption by 20 percent. Thus, the transaction tails assay is also one of the most important variables affecting uranium consumption.

The optimum tails assay is strongly affected by the relative costs of separative work and natural uranium. Nuexco has used a tails assay of 0.25 w/o U_{235} in calculating uranium consumption over the study period. If the laser enriching process can be utilized near the end of the study period, and if its costs are within the range predicted by DOE, then the enrichment tails assay could become much lower, even below 0.2 w/o. Figure 6 shows the cost of one kilogram of uranium enriched to 3.4 w/o for tails assays in the range of 0.1 to 0.5 w/o, a natural uranium price of $80/Kg as UF_6, and SWU prices of between $50 and $125 per SWU. These curves are valid if there are no surcharges for altering the tails assay. The minimum of each curve shows the tails assay that yields minimum product cost. For $100 SWU and $80 per kgU as UF_6, the optimum tails assay is 0.251 w/o.

— Recycle of Uranium and Plutonium – A number of countries are or will be operating chemical reprocessing plants for the separation of uranium, plutonium, and fission products. Later, the recovered uranium and plutonium can be recycled into reactors, thereby reducing the need for fresh natural uranium and separative work. However, on a worldwide basis, the reduction in natural uranium consumption during the study period is small, especially if recovered plutonium is chiefly utilized in breeder reactor programs. Therefore, Nuexco has not explicitly incorporated recycle into the consumption calculations. It is, however, factored into Nuexco's estimates of unfilled requirements.

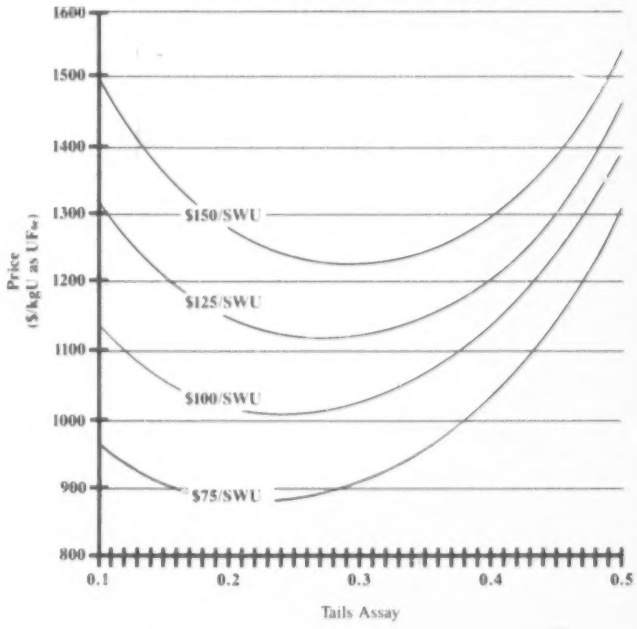
— Fuel Preparation Lead Times – As described earlier, natural uranium is needed 18 months to two years prior to the time that the fuel assemblies to be produced from such material are to be utilized in a reactor. These lead times are not likely to change in any major way such as to affect the consumption calculation results.

— Processing Losses – The consumption calculations are based on a yield during conversion of 99.5 percent and an allowance of one percent for extra material to be provided to the fuel fabricator.

Thus, due mainly to Nuexco's emphasis on growing capacity factors, the latest forecast of world uranium consumption shows a marked increase over the previous Nuexco forecast of January 1985. The current reference case projection also is approximately 12 percent higher than the Uranium Institute's latest forecast.

Figure 6

COST OF ONE KGU ENRICHED TO 3.4% AT VARYING TAILS ASSAYS
Zero Surcharge Basis
(Assumes $80/kgU as UF_6 feed)



Comparison of Nuexco and Uranium Institute Forecasts

The Uranium Institute's recently published report contains the Institute's forecast of nuclear electric generating capacity and the corresponding uranium demand. The Institute's nuclear generating capacity forecast is greater than Nuexco's and its uranium demand forecast is lower than Nuexco's. Some of the reasons for these differences are outlined below.

The Nuexco forecast does not incorporate the effect of recycle of recovered products from the reprocessing of spent fuel. Nuexco's forecasts of the world uranium supply-demand balance treat fecycle as a source of added supply rather than as a reduction of demand. Hence, the comparison between the Institute's forecast and Nuexco's, shown in the following table, is based on the respective forecasts *excluding* the reduction due to recycle.

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COMPARISON OF FORECASTS

Year	Uranium Institute[1]		Nuexco	
	Generating Capacity (GWe net)	Uranium Demand (Million Pounds U_3O_8)	Generating Capacity (GWe net)	Uranium Demand (Million Pounds U_3O_8)
1986	228.9	110.0	228.4	115.4
1990	291.7	115.7	283.1	124.2
1995	330.5	128.4	308.3	132.0
2000	372.9	136.0	345.9	144.6
Average GWe	311.6		295.9	
Total Uranium Demand		1,852		1,958

[1]SOURCE: *The Uranium Market 1986-2000*. Published by the Supply and Demand Committee of The Uranium Institute, December 1986. ISBN# 0 946 777 08X.

The average installed nuclear electric generating capacity over the study period (assuming a straight line interpolation between 1995 and 2000 for the Uranium Institute's data, since those years are not shown in its report) is determined to be 311.6 GWe (net) by the Institute and 295.9 GWe net by Nuexco, the latter being lower by 5.0 percent.

The total of reactor uranium requirements (Nuexco refers to this as "consumption") over the period (1986 to 2000) is 1,852 million pounds U_3O_8 in the Institute's forecast and 1,958 million pounds U_3O_8 in Nuexco's forecast, the latter being 5.7 percent higher. Adjusting for the five-percent difference in installed capacity makes the Nuexco uranium requirements forecast 11.3 percent greater than the Institute's. Thus, if Nuexco's installed capacity forecast were increased to correspond with the Uranium Institute's forecast, Nuexco's uranium consumption forecast for the period would be increased to about 2,062 million pounds U_3O_8, from 1,852 million pounds (an increase of 11.3 percent).

Nuexco's forecast is based on an enrichment tails assay of 0.25 w/o throughout the period. The Institute uses a declining tails assay, reported as 0.25 w/o in 1985, 0.22 w/o in 1995, an 0.20 w/o in 2000. Assuming straight line interpolation between the reported data points, the weighted average (weighted by uranium demand) tails assay used by the Institute over the period is 0.225 w/o. If Nuexco had used 0.225 w/o tails in its calculations, its uranium demand would have been about 4.4 percent lower. Therefore, if Nuexco's forecast were adjusted for both the capacity and the tails assay differences, it would result in 1,971 million pounds U_3O_8 consumption over the period, compared with 1,852 million for the Institute; Nuexco's figure is still 6.4 percent higher.

A rough comparison of the nuclear plant capacity factors used by the Institute and Nuexco for the projections indicates a close similarity. The Institute uses a single value of the capacity factor for each country (for all reactor types in the country), whereas Nuexco uses a single value for *each reactor type* in each country. This procedure gives Nuexco data a multiplicity of values for each country, therefore making a comparison with the Institute's data difficult. However, it appears that little of the remaining difference is attributable to this potential discrepancy.

Instead, the uranium consumption per unit of electricity produced (in units such as pounds U_3O_8 per MWe-year [net] of electricity production) is apparently responsible for the majority of the remaining 6.4-percent discrepancy. At the start of the study period, the values used by the Institute and Nuexco are very similar. However, the Institute assumes a substantial reduction in the unit consumption rate over the years, whereas Nuexco assumes only a small reduction. For example, the Institute assumes a reduction of 10 percent by 1995 and 20 percent by 2000 for the consumption of uranium per MWe-year of electricity production in France, attributable to more efficient utilization of the fuel (and not due to recycle or other external changes). For other major consuming countries, the Institute uses 15-percent improvement by 1995 for Germany and Japan, and 5 percent by 1995 and 10 percent by 2000 for the USA. Nuexco's assumptions for this type of improvement in fuel utilization are in the range of one to two percent. Thus, the 6.4-percent normalized difference between Nuexco data and the Institute's data is attributed to the Institute's optimism regarding future improvement in fuel utilization in the existing reactor types.

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RECENT DEVELOPMENTS

UNITED STATES

Market participants continue to await action by the US Tenth Circuit Court of Appeals on DOE's appeal of Judge Carrigan's order in the uranium producers' litigation. The litigation is also of concern to members of Congress. However, many are content to let the Appeals Court dictate a solution, since conflicting interests within Congress are so polarized over how to solve the problems. In the meantime, a number of other nuclear-related issues are drawing attention.

1. A bill clearly intended as retaliation against Canada's UF_6 upgrading policy is under consideration in the House of Representatives. The Trade and International Economic Policy Reform Act of 1987 (H.R. 3), now under review in committee, would impose a tariff of $3.00 per KgU as UF_6 on uranium imports from any country requiring that uranium be upgraded as a condition of export. Should the proposed legislation ultimately become law it could have a large negative impact on Canadian uranium sales to the USA.

2. The Treasury Department still has not issued final regulations for the implementation of the US ban on the importation of South African uranium. The other provisions of the South African sanctions bill went into effect on January 1, 1987 as scheduled, but imports of South African origin uranium in the form of UF_6 or for processing and reexport (transient imports) have continued. Such imports can be expected to continue at least through June 30, based on the rumored six-month grace period, during which the Treasury Department may be waiting for Congressional clarification of the ambiguous language in the Anti-Apartheid Act.

If the grace period began on January 1, and if the Treasury Department issues final regulations by June 30, then imports of South African uranium might cease as of that date, depending on the scope of the regulations. However, an alternate scenario is possible. Although the Treasury Department has acknowledged that the Nuclear Regulatory Commission (NRC) is the agency responsible for licensing uranium imports, the NRC has neither revoked nor suspended any licenses for the importation of South African uranium. Rather, the NRC adopted a policy effective January 1, 1987 requiring holders of general import licenses to apply for a specific license to import South African uranium. The NRC also "requested" holders of valid pre-1985 specific import licenses to "refrain from importing any material of South African origin" while its review is underway.

The latest controversy over sanctions developed when the Lawyers Committee for Civil Rights under Law, seven Congressmen, and five other organizations intervened in opposition to eight applications for new specific import licenses that have been filed with the NRC. The same group also petitioned the NRC to revoke eleven specific licenses that had been in effect since before 1985 and which are still valid for transient imports. The intervenors claimed that Section 309 of the sanctions bill bans all chemical forms of uranium imports for domestic use or for enrichment and reexport and that to grant new specific licenses or to honor the old ones would circumvent the purposes of the Act. The Treasury Department had been intending to allow the importation of UF_6 intended for reexport, as opposed to U_3O_8, on the basis of its interpretation of the legislative history of the bill. However, the so-called legislative history on which the Treasury Department had intended to rely is highly controversial. It is supposed to have taken the form of a colloquy, which is sometimes spoken or inserted in the record in written form to record the debate and state the intentions of Congress. It is not clear that any such debate or written colloquy was ever approved officially.

3. The renewal of the Price-Anderson Act, which expires in August 1987, is of utmost concern to utilities. If the Price-Anderson Act is not renewed, there could be a significant adverse impact on the value of a utility's stock, the ability to raise capital, renewal of insurance, bonding, etc. However, a renewal of the Act could bring about as much as a tenfold rise in the amounts for which a utility would be liable. (See the article on the Price-Anderson Act in Report 219, November 1987.)

4. Some form of the "Uranium Revitalization & Tailings Reclamation Act of 1986" probably will be reintroduced by Senator Domenici (R, New Mexico) and others in the Senate. Congressman Richardson (D, New Mexico) and others introduced legislation in the House of Representatives on March 15, 1987 (H.R. 1456) that would, among other things, limit uranium imports to no more than 20 percent of US reactor requirements.

5. The House Interior & Insular Affairs Committee and the Energy & Commerce Committee held hearings on February 10 and 11, 1987, on DOE's 1988 budget request. During the hearings, Congressman Morris K. Udall (D-Arizona), Chairman of the Interior & Insular Affairs Committee, who was a key architect of the Nuclear Waste Policy Act (NWPA), was extremely critical of DOE's handling of the program. Many members expressed skepticism at DOE's ability to carry out the NWPA. The program's Mission Plan amendment that would cancel the second repository was also criticized. (See the NWPA article in Report 221, January 1987, and the update in this month's Report.)

Despite the admittedly urgent nature of the complex issues, it will be very difficult to pass any nuclear fuel cycle legislation during the current session of Congress. The Reagan

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Administration is opposed to import restrictions and to any write-off of DOE's purported $7.5 billion debt below $3.4 billion. Spearheaded by Senator Domenici, the Senate Energy & Natural Resources Committee supports a position that would establish the debt at approximately $300 million. Conversely, the House Energy & Commerce Committee wants $7.5 billion of debt recovered.

The view of some in the government is that Congress originally intended to provide the uranium industry with needed protection, and that the industry is now entitled to the import relief embodied in the Atomic Energy Act [Section 16lv (42 U.S.C. 220lv)]. If legislation is introduced to repeal Section 16lv of the Atomic Energy Act, it will face determined opposition from western states Congressmen. Due to the nature of the political process, such an action could jeopardize other nuclear-related legislation, such as the renewal of the Price-Anderson Act and any potential fix for the Nuclear Waste Policy Act.

* * *

This article is an update of a detailed article on the Nuclear Waste Policy Act of 1982, which appeared in Report 221, January 1987.

In late January, the Department of Energy (DOE) sent to Congress a proposal that officially postponed the date on which DOE expects to be able to receive high-level waste materials into the first repository specified under the Nuclear Waste Policy Act of 1982 (NWPA). In addition, the proposal postponed the date expected for opening of a Monitored Retrievable Storage (MRS) facility, assuming one is authorized by Congress, and it reaffirmed the indefinite postponement of the siting process for the second repository specified under the NWPA.

The recent announcements came in a revision to DOE's Mission Plan, a document outlining the Department's direction in implementing the NWPA. Postponing the completion date of the first repository sets back the timetable to 2003, five years later than the 1998 date originally mandated under the NWPA. The shift in schedule for the MRS, which has yet to be officially authorized by Congress, delays by two years the expected date for taking spent fuel, to 1998.

The postponements are not a surprise. In Congress, critics of DOE's handling of the repository program have used the occasion to question again the legality and political neutrality behind DOE's making such plans without Congressional authorization. Given the many legal obstacles blocking DOE's efforts to find potential sites for the repository, and the intense controversy generated by nearly every step of the process, the ability of DOE to complete a repository by the mandated time had for some time been seriously questioned.

Under the *current* Mission Plan schedule, site characterization, requiring exploratory shaft construction, on the volcanic tuff and basalt sites (in Nevada and Washington) would have begun in the fall of 1986. Construction at the salt formation site (in Texas) would have begun a year later, in late 1987. Now, under the proposed plan, the Washington and Nevada sites would begin the construction phase of site characterization in mid to late-1988, and the Texas site in late 1989. The end of the site characterization phase now would be scheduled for 1992 and 1993. Evaluation of the results of site characterization would take about three years, until the end of 1994, when DOE would recommend one site to the president for approval or disapproval.

Under the proposed schedule, the final site selection report, which would name the single site that DOE recommends to the president from the three candidate sites now being evaluated, would be issued in 1994. Application to the NRC for the license necessary to proceed with construction would take place soon after, in early 1995. DOE's projected schedule then anticipates construction of the repository beginning about three years later, in early 1998. The first operating phase, in which the repository would begin receiving spent fuel from commercial reactors, would start in 2003. By 2005 the second phase would begin, which would allow the repository to start accepting waste from military and defense storage installations.

The MRS selection and siting process, while not as controversial or complicated as the one involving the permanent repositories, also has been stalled by legal obstacles. The postponement of the MRS in the Draft Mission Plan appears to acknowledge that those legal problems will not be as easily solved as seemed to be the case in November 1986, when a federal appeals court ruled in favor of DOE, by dissolving an injunction that prevented DOE from formally submitting an MRS proposal to Congress. In the draft plan, DOE asked that the MRS facility be limited to storage of no more than 15,000 metric tons of commercial spent fuel, and not to allow the MRS to receive any waste until construction authorization of a first repository is made.

If anything, criticism of DOE has intensified since the new Mission Plan was released. The legality of DOE's decision to reschedule the repository program had been the subject of controversy since Secretary Herrington announced, in May 1986, that DOE was effectively stopping progress on the search for a second repository. Under the NWPA, a second repository was no less critical than the first, with a schedule just as precisely fixed by the legislation. Now, as changes in the schedule for the overall program are proposed, the ques-

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tion again arises of DOE's authority to decide scheduling of the NWPA.

The status of an MRS facility becomes potentially even more important under the revised schedule. Without an MRS facility in operation and receiving spent fuel by 1998, the legal contract that DOE has with utilities to accept their spent fuel by 1998 cannot be met. If DOE fails in its obligation to accept the waste, utilities could seriously question the status of the funds they have paid into the Nuclear Waste Fund, and the timetable that DOE and the Congress established for payment of the funds. Without an MRS, there is some doubt whether available near-term storage of spent fuel will not become overburdened, especially if schedules slip again. At present, the quantity of spent fuel stored at reactors almost equals the 15,000 metric ton limit just proposed for the MRS facility. By 2000, that quantity will be considerably greater.

The revised Mission Plan has, most of all, given DOE's critics a new platform to threaten the agency with a comprehensive restructuring of DOE's role in implementing the siting process. The inability to meet the originally legislated schedule, the political polarization caused by the siting process and the impression given by DOE of autocratic behavior, and the widespread loss of credibility in DOE's ability to administer the program, have all contributed to new uncertainties regarding the present and future course of the NWPA repository program. How the problems will be resolved will greatly affect not only the nuclear industry, but also every person in the USA.

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SOLUTION MINING OF URANIUM, Part 2

Introduction

Solution mining of uranium has undergone a long process of development, during which many geological, technical and regulatory problems have been overcome. Solution mining provided about eleven percent of US uranium production in 1986, and the technology offers potential for a considerably greater share of production in the future. The problems involved in restoring the groundwater aquifers once mining has been completed are now largely known, and the uncertainties that characterized many solution mining projects in the past have diminished. Regulations governing solution mining also have become relatively well established, allowing more realistic estimates for time schedules. Even so, only a few solution mining projects are now in commercial operation in the USA, out of more than forty projects which reached at least the pilot plant stage. Given the advances made in the application of solution mining technology, the main problem facing solution mining in the USA is the depressed state of the industry as a whole.

Background

The first uranium solution mining project of record was started by Utah International in 1961 in an ore deposit at a depth of about 350 feet in the Shirley Basin district of Wyoming. The property had been mined by conventional underground methods starting in 1960. In association with that conventional operation, for the next two years Utah experimented with different well completion techniques, well patterns, and lixiviants (the solutions used to dissolve the uranium). Finally, mining began in 1963 using "four-spot" well patterns — one recovery well placed downstream from three injection wells. Ground water flow moved the sulfuric acid lixiviant into the low-pressure area created by pumping the production well. The project operated with some success, under the Atomic Energy Commission (AEC) buying program, until 1969 when it was converted to open-pit mining.

By 1972, four pilot solution mining projects had been started in the South Texas district. The rising price for uranium stimulated interest in the technology and by 1976 nine additional pilot projects were active in Wyoming and Texas. By 1983, when mining activity began to decline drastically, 48 initial pilot projects had been started, eventually leading to the development of 21 commercial operations. The early research and development efforts established a new and efficient in situ leach technology that was generally compatible with environmental requirements. Recovery increased from original levels of about 20 percent of the uranium contained in the formation to over 80 percent in some cases. Application of solution mining technology also proved to be considerably less complicated than for conventional projects. Most equipment is readily available without special design or manufacturing; furthermore, plant and subsurface operations require only low pressures, low temperatures, and low concentrations of chemicals. The foregoing factors contribute directly to improved employee safety and health, and lower operating costs.

Many of the current generation of solution mining projects are operated by small companies whose primary business activity is uranium mining. In this type of company, many key employees have expertise in more than one area, which greatly reduces the number of employees required. Some companies have been able to minimize exploration and research and development costs because of their operating experience and innovative techniques, allowing them to remain competitive in the current market.

Current Projects

There are currently eleven active commercial or R & D (pilot) solution mining projects in the USA, down from a total of 48 in 1983 (see Table 5 for a list of major projects). Seven of the eleven are located in Texas where 1986 output was approximately 1.5 million pounds U_3O_8. Of these, however, only one project is operating at near capacity — the Mt. Lucas project of Everest Minerals Corp., in Live Oak county (Figures 7, 8). Everest is producing at an annual rate of over 500,000 pounds from a 3 million pound reserve discovered in the Goliad sand/conglomerate formation. The project's first wellfields are in the early stage of restoration; production is sustained by new wellfield development. Exploration for additional ore reserves continues in an effort to extend the operating life of the project.

In addition to Mt. Lucas, Everest plans to bring its Tex-1 property, located near Hobson, in Karnes County, Texas into production by late 1987. Approximately 600,000 pounds of uranium are estimated to occur in the Jackson Formation. Pilot testing was successfully completed in 1986 followed by application for a permit to mine. By early 1988, Everest may also undertake production from its Gruy lease, located in Duval County, with a reserve base of about 500,000 pounds U_3O_8, in the Oakville Formation. R & D tests are scheduled for later this year. The annual production rate for both properties remains to be established.

The 50-50 joint venture between US Steel and Niagara Mohawk Uranium Corp. (NMU) currently produces from

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Figure 7. Satellite ion exchange unit at Everest Minerals' Mt. Lucas Uranium project.

two properties in Live Oak County, Texas. At the Clay West property, the annual production rate for the last nine years has averaged over 750,000 pounds U_3O_8. Restoration is already in progress over much of the deposit and plans call for full restoration to begin in 1987. The project on the Burns lease is presently in the final stage of restoration. This property adjoins Clay West on the southeast, and has averaged over 500,000 pounds production annually during the last nine years; production was less than 100,000 pounds in 1986. US Steel introduced satellite production centers on this lease about eight years ago, a concept that spread throughout the industry as a potential cost-cutting measure.

Intercontinental Energy Corp., (IEC) is shifting activities to the Lamprecht lease from the neighboring Zamzow lease in Live Oak County. The Lamprecht lease was obtained from Wyoming Mineral Corp., under the provision that IEC would mine the remaining ore and eventually complete restoration of the project. IEC has prepared the deposit for full-scale mining to begin this year, continuing for the next two to three years. Restoration will probably begin by 1989 or 1990. The ore is confined to the Oakville Formation.

Mobil Oil Corp. continues to produce from its El Mesquite property located in southern Duval County. The project has been in production since 1979, averaging about 300,000 pounds U_3O_8 per year. However, the production rate is declining as the restoration phase begins in mined out areas. The ore occurs in the Catahoula Formation.

Uranium Resources, Inc., (URI) is in the final stage of restoration at its Bruni and Benavides properties in southern Duval County. Attention is now focused on the Kingsville Dome property located in Kleberg County. URI has recently acquired full interest in the property, through acquisition of the 50-percent interest controlled by Western Nuclear, Inc. The project was given a permit for mining in late 1986 after a series of public hearings and review by the Texas Department of Health and the Texas Water Commission. URI is preparing to begin mining by late 1987 or early 1988 at a rate as yet undetermined. Reserves have been estimated to exceed 4 million pounds U_3O_8 at an average grade of 0.15 percent uranium. The ore occurs in the Goliad Formation around the flanks of Kingsville Dome, a piercement-type salt (or shale) structure.

Chevron Minerals Corp., is in the last stage of restoration at its Palangana Dome property, Duval County, Texas, which it acquired from Union Carbide. Production in 1986 was less than 50,000 pounds U_3O_8, all of which was extracted during restoration procedures. The ore occurs in the Goliad Formation which has been tilted and faulted along the edge of the dome structure. Union Carbide Corporation attempted to mine the deposit, which has reserves estimated in excess of 3 million pounds U_3O_8, by underground methods in the late 1950s. Mining was terminated due to adverse conditions of ground-caving, excessive amounts of groundwater, and hydrogen sulfide gas. The property was placed on standby for a number of years before solution mining was introduced about 1976. The mine will be fully restored this year, ending over 25 years of interest in the deposit.

In Wyoming, three solution mining projects are located in the Powder River Basin, in Converse and Campbell counties. The joint venture of Everest Mining Corp. and Wold Nuclear (70 percent and 30 percent, respectively), is awaiting approval from the Wyoming Department of Environmental Quality (DEQ), to mine the Highland deposit which was purchased from Exxon Nuclear Company, Inc. in 1983. More recently, the joint venture acquired the adjoining North Morton Ranch property from Tennessee Valley Authority (TVA) consolidating its control of known ore reserves totaling about 30 million pounds U_3O_8, occurring in the lower part of the Wasatch Formation. Pilot testing of the deposit has been in progress for about two years and the joint venture is now ready to start construction of mining facilities and begin mining by early 1988.

The joint venture's pilot program is actually an extension and verification of a similar program conducted by Exxon from 1972 through 1974, and again from 1978 through 1981. The success of the two Exxon programs was an important factor in the decision to acquire the properties. Exxon operated a pilot plant at a rate of 60 gallons per minute with four

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wellfield patterns. Restoration of the pilot wellfields was in progress at the time of the purchase and is now nearing completion.

Sequoyah Fuels Corp., (Kerr-McGee Corp.) continues to operate a small solution mine on its Bill Smith ore deposit, located to the southwest of the Highland mine. Sequoyah originally mined the deposit by conventional underground methods starting about 1976. The underground mine was placed on standby in 1979 and interest shifted to solution mining of deeper ore zones. The initial pilot test started in 1981 using a flow rate of 100 gpm from a wellfield covering one acre. After a successful period of mining and formation restoration, the test is now in the one-year stability period required by the DEQ. A second pilot test was recently started in another area of the deposit, covering 1.5 acres and using a flow rate of 150 gpm. It is expected to operate for two years before restoration is initiated. The mining has taken place in two different mineralized sand horizons of the Wasatch Formation.

Malapai Resources Corp., a subsidiary of the AZP Group, Inc., is completing its initial pilot testing on the Christensen Ranch project. The testing, which consisted of two "five-spot" patterns, began in August 1986 and was completed in December 1986 on the Willow Creek deposit. A restoration permit has been issued for the test site and restoration is ready to begin. The company has filed application for a mining permit on the deposit.

Malapai also has an option to purchase the Irigaray deposit and solution mining recovery plant from the Uranium Division of Westinghouse Electric. The plant has an annual capacity of about 500,000 pounds U_3O_8. The property is already fully licensed and could be in production within the short period required for startup preparations. Malapai could fill early delivery requirements from the Irigaray project if necessary. The ore on both deposits occurs in the Wasatch Formation.

In Nebraska, Ferret Exploration Company is operating a solution mining pilot on its Crow Butte property near Chadron. Construction of the pilot plant began in June, 1986 and testing began in August, using two well patterns and a flow rate of 100 gpm. Production from the small pattern (30 foot well spacing) ended in January and preparations for restoration are currently in progress. The larger well pattern (66 foot well spacing) is still in production, maintaining a stable flow and production rate. This wellfield will serve as a basis for expanding to commercial production in the next phase of project development. Project timing is uncertain, but commercial production at an annual rate of 500,000 pounds U_3O_8 by 1989 or 1990 is a possibility. The ore horizon is in the basal Chadron Formation.

Regulatory Requirements

Compliance with regulatory requirements is necessary before pilot testing and commercial operation of a solution

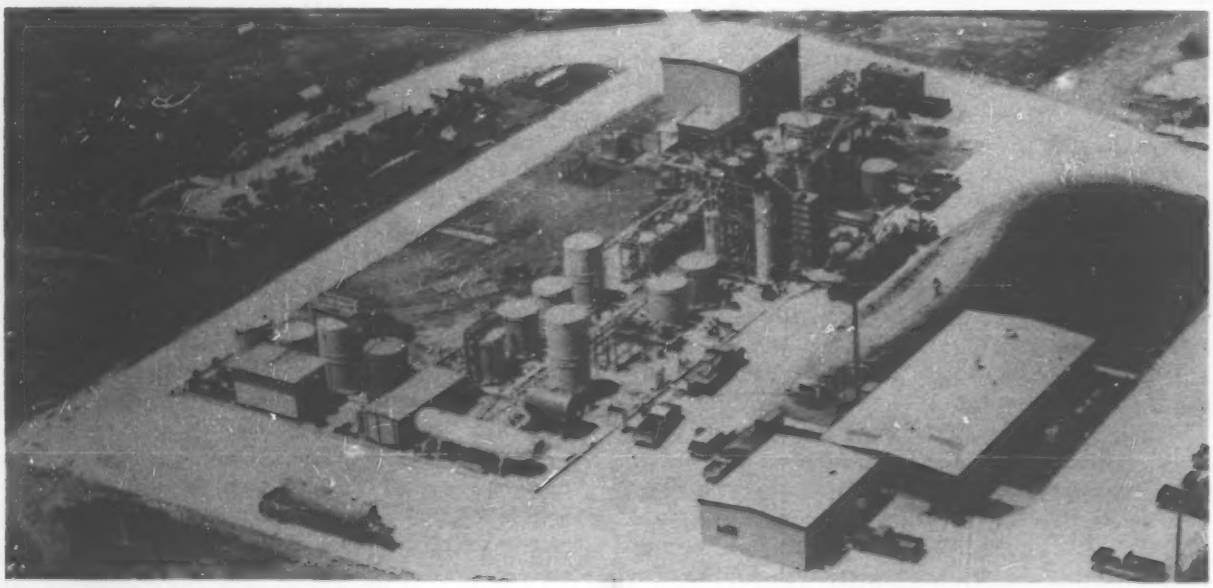

Figure 8. Everest Minerals' central processing plant at Hobson, Texas.

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mining project can begin. Although all mining requires full compliance with the Safe Drinking Water Act of 1974 and the Federal Water Pollution Control Act, solution mining projects may be subject to even stricter regulations. Regulatory agencies include the Environmental Protection Agency (EPA) with jurisdiction over both water acts, and the Nuclear Regulatory Commission (NRC), with jurisdiction over radioactive materials licensing, and/or various state and county agencies.

Any state which creates its own enforcing agencies and formulates its own requirements for environmental impact, which must be as stringent as federal requirements, is classified as an agreement state. Currently Texas, with two agencies to regulate solution mining, is the only active agreement state. (Colorado and Washington are also agreement states, but have no history of solution mining.) The Texas Department of Health is responsible for issuing and regulating radioactive materials licenses for uranium ores and radioactive by-products (usually limited to medical products). The Texas Water Commission issues and regulates underground injection control (UIC) and aquifer exemption permits (from the Safe Drinking Water Act of 1974), plus a Class I permit for deep well disposal of waste materials, and a National Pollutant Discharge Elimination System (NPDES) permit, for surface discharges that directly affect navigable streams.

A state electing to operate under the jurisdiction of at least one federal agency and one or more state agencies is considered a nonagreement state. Utah, Arizona, Wyoming, Nebraska, and New Mexico are nonagreement states. The permitting policies tend to be less well defined in these states; however, the latter three states do have policies for primary control over UIC and aquifer exemption permitting, plus surface and underground discharge of waste materials.

Each state requires some degree of research and development (pilot testing) prior to giving approval for commercial operations. R & D permits are based on a fairly limited exposure of the surface and subsurface environment to actual operating conditions. The primary function of R & D is to demonstrate aquifer restoration capabilities as they may apply to a commercial-sized operation, although it also enables an operator to establish potential mineral recovery rates.

After the pilot program has proven successful, the operators of a project may file for permission to expand the project into a commercial operation. At this time new applications must also be filed to cover environmental concerns expected under full-scale operation. Again, the requirements for each state differ. An environmental impact statement (EIS) may or may not be required, but usually a detailed hydrological report and a mining license are required. To save time, it is an accepted practice to file the application for a mining license prior to demonstrating final restoration results. Once approved and licensed, a project is be allowed to continue commercial operations under the terms and conditions defined in the final permit applications, for as long as the required environmental controls are properly monitored and maintained.

Actually, solution mining requirements vary considerably according to local geology, hydrology, geochemistry, and surface environment. In Texas, permitting may be accomplished in 12 to 24 months, depending upon the location (by county) of the project. Texas has a broader working knowledge of solution mining than do most states because of its long experience with the oil and gas industry, and more recently, with numerous commercial-scale solution mining projects. In the other states mentioned, the permitting sequence may take three to five years, primarily due to implementation of both federal and state regulations and a lack of regulatory experience in solution mining.

Geological Requirements

As covered in Part 1 of this article (Report 220, December 1986), the geological limitations for effective solution mining of uranium are relatively strict, and formations amenable to this type of mining are found much less frequently than are those suitable for conventional uranium mining operations. One of the primary limiting factors is that the uranium-bearing host formation must be tightly confined within an aquifer, which must exhibit certain characteristics. In particular, the impermeable lower formation containing the aquifer water is necessary to provide control over downward migration of the lixiviant solution. The natural aquifer fluid also is necessary to form the leach solution; to move the leach solution through the mineral deposit; and to provide fluid movement that aids in aquifer restoration.

In addition to aquifer requirements, orebody characteristics also are subject to certain requirements. The uranium contained in the orebody must be in an oxidized state, it must be located a relatively shallow depths, it must exhibit relatively high rates of permeability, it should contain little or no organic matter, and ideally, the ore zone should be positioned near the base of the aquifer.

These geological requirements are mainly found in roll-front deposits within the relatively recent paleochannel sand units in Tertiary formations. The older and deeper uranium-bearing sandstone formations, such as are found in Jurassic sandstones in the Grants mineral belt in New Mexico, tend to be more highly compacted, exhibiting considerably lower

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formation permeability. In general, greater formation depth usually results in increased exploration, development, production, and operating costs to a project, as well as frequently offering relatively less formation permeability.

Wellfield Procedures

In order to achieve maximum recovery efficiency, the mining and milling facilities of any solution mining project are operated under strict controls. Wellfield technology is complicated, and often is subject to many potential problems associated with hydrology and geochemical reactions. In addition, mechanical malfunctions of wellfield equipment can potentially shut down much of a project's production. Wellfield design and operating characteristics of equipment are, therefore, critical to a successful mining project. In general, much of solution mining technology is taken directly from the petroleum industry. Well completion practices and equipment, plus wellfield management procedures, have become somewhat standardized over the past few years, although they are naturally subject to operator preference.

Both well spacing and type of equipment must be decided in advance of regulatory approval and carried out according to plan; any revisions may be subject to new approval and subsequent delay. All materials going into the well (primarily casing and screens) must be of sufficient quality to endure the mechanical and chemical stresses imposed throughout the life of the project. This requirement applies to injection wells, production wells and monitoring wells, each serving separate functions.

Typically, wells are drilled 4 to 6 inches in diameter, into the impervious formation immediately below the mineralized zone. The drilling is done by conventional rotary equipment, which usually requires the use of a drilling fluid. The fluid, or "mud", normally is made up of ground water from the mineralized zone, with polyanionic cellulose polymers, guar gum, or bentonite additives. The first two are the most suitable since they accomplish everything a drilling mud should, plus they have less tendency to seal off the formation, which can be extremely detrimental to the leaching process.

It is common practice to run geophysical profiles of each well (including exploration holes) following drilling and clean-out procedures. The profiles measure resistivity, natural gamma radiation, and electrical conductivity of the formations, enabling an interpretation of the geology, hydrology, and most importantly, the depth, thickness, and grade of uranium contained in the ore zone. A computer model of the ore body developed from this information can be a valuable tool for developing a mine plan.

After a well is drilled and logged, the next step is to set the casing, which typically is made of polyvinyl chloride (PVC). This type of casing has adequate tensile strength for use to a depth 800 to 900 feet, and it is the lowest-cost material available. Fiberglass and steel casings cost more than PVC but their use may be required for deeper projects. Once the casing is properly aligned in the hole, it is cemented in place, usually from a point immediately above the ore zone to the surface. Cementing prevents the vertical migration of aquifer water and/or lixiviant by sealing off the space between the well wall and the outside of the casing. (Restoration of each well is completed by cementing inside the casing from bottom depth to the surface.) Where the casing goes through the ore zone, it may be slotted or replaced by a fine filter screen in order to allow the lixiviant to circulate freely in or out of the openings. Fine, clean gravel frequently is packed outside the screen liner, especially in the production (recovery) wells. This allows a greatly increased flow-rate of fluids and minimizes lost production time due to sanding or silting of the screen.

Several different well configurations have been commonly used in uranium solution mining, applying the principles of petroleum reservoir engineering. Perhaps the most favored pattern is the "five-spot", with the production well at the center and four injection wells at the corners. A grid of "five-spots" can be effectively placed over the full width and length of an ore deposit. Corner spacing may vary from 50 feet to about 200 feet, depending on formation permeability and characteristics of the aquifer and mineralized zone. Other successful well patterns include the "seven-spot", with six injection wells, and the "staggered line drive", designed to cover the geometric shape of an ore body. Under extreme conditions of mining small ore pods, the "push-pull", or "one-well" technique is used. In such a case, the lixiviant is injected into the ore zone to dissolve the uranium, and is recovered a short time later through the same hole. The one-well technique is commonly used during the pilot testing phase of a project.

Monitor wells are important parts of solution mining projects, both for controlling the production process and for regulatory reasons. These wells may be situated within or outside the ore deposit and are used to monitor the migration of lixiviant both inside and outside the deposit. Taking water samples from monitor wells is an ongoing part of the mining process.

The potential for escape of lixiviant from the wellfield area can be reduced by withdrawing up to ten-percent more ground water than is recirculated. This technique creates a low-pressure zone that allows an influx of native ground water from around the wellfield perimeter, thereby containing

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the lixiviant. The excess water may then be pumped down deep disposal wells or sent to a lined evaporation pond.

To keep all wells clean and in production requires continuous maintenance, and review of well performance is almost a daily chore. A decrease in the rate of production can indicate any of several problems, each requiring a special procedure to remedy. The more common corrective procedures include:

1. Flushing the well with bleach to kill bacteria;
2. Creating a surge and back flow of fluids to clean plugged wells;
3. Injection of acidic chemicals to remove calcite and iron scale;
4. High-pressure jetting to mechanically clean screens;
5. Removing and reinstalling liners or regravelling the screen packing.

In order to avoid reduced production levels due to inoperative wells, it is desirable to have several wellfields in production at any time.

The Ion Exchange Process

Lixiviant pumped to the surface via the production wells contains leached uranium in solution. The uranium is recovered by passing the solution through an ion exchange system, located either at a satellite facility near the wellfield or at a central recovery plant. Generally, the solution is first transfered from the well to a filtering circuit to remove sand and other debris, although gravel-packed wells may reduce or eliminate the filtering requirement. Next, the solution is passed through ion exchange columns filled with anionic resin beads that continuously attract the uranium from the solution (see Figure 9).

The uranium must be removed from the loaded ion exchange resin using a solution called an eluant. This process (elution) cleans the resin beads of uranium so they can be reused in the ion exchange circuit. In most plants multistage continuous elution is used, although the use of single stage and two stage elution can give satisfactory results, but with less efficiency. Eluants may consist of ammonium carbonate, sodium carbonate, or sodium chloride-sodium carbonate. The latter eluant is often preferred because the chloride ion readily displaces the uranium ion complex, allowing a more complete cleansing of the resin.

Elution is followed by precipitation, beginning with the addition of acid, usually sulfuric acid, to the uranium-rich eluate. The acid removes the anion complex, thereby allowing precipitation by the addition of ammonia, or in some cases hydrogen peroxide or sodium hydroxide. The ammonia/uranium reaction creates ammonium diuranate (ADU), or yellowcake, the most common commercial uranium product.

Molybdenum often is found with uranium in the type of sandstone deposits most suitable to solution mining. If molybdenum is present in the eluate, the addition of hydrogen peroxide may be required to separately precipitate out the uranium. Then, activated carbon columns are used to remove molybdenum from the eluate stream. It can then be disposed of as a solid waste, or collected as a co-product. The exhausted eluate is a saline waste stream that can be reactivated for reuse in the elution column, although this option is often uneconomical. Generally the waste eluate is disposed of by injection into a deep salt water aquifer, or by evaporation.

The uranium concentrate (yellowcake) is washed with fresh water to reduce the chloride content, and either filtered or centrifuged to reduce the moisture content. Next, it passes through a dryer which may consist of a heated rotary spiral, a rotary hearth, or a batch vacuum dryer. The vacuum drying method often has lower operating costs and is environmentally preferred because air emissions are negligible. Some solution mining projects, however, produce a uranium slurry rather than a dry product. The slurry has been acceptable only at the Kerr-McGee conversion facility located at Gore, Oklahoma.

Conclusion

The extraction of uranium by solution mining techniques constitutes the primary advancement in uranium recovery technology during the past 25 years. Originally, the process was developed as an alternative to conventional mining methods, in order to economically exploit lower grade deposits. Although application of the solution mining process is limited geologically to certain types of sandstone deposits, in these settings it can offer definite advantages over most conventional operations, including the potential to turn a non-profit project into a profitable one. Naturally, each project must be considered individually, weighing the results of engineering and economic studies.

In a technical sense, the advantages of solution mining over conventional uranium mining methods are primarily found in reduced requirements for operating equipment, plant energy, and skilled labor. In addition, this method totally eliminat s conventional open pit or underground mining and ore processing, which can represent 60 percent or more of project costs. The main disadvantages are the possibility of lower and slower uranium recovery rates, although this may be a site-specific situation, as well as possibly difficult and expensive project restoration.

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There are several potential cost benefits to solution mining projects.

1. A smaller land position is usually needed, as well as somewhat more limited exploration requirements (although this may differ for each project due to land/lease status and local geologic characteristics).

2. There is normally a reduced need for orebody development and plant construction.

3. The lead time from initial development to production is often shorter.

4. Smaller capital investment may be required, in particular, avoidance of the high costs associated with large volume reclamation projects that are part of conventional mining and milling methods, including disposal of mine water.

5. Improved safety standards for employees may be achieved through minimized exposure of employees and surrounding population to plant dust and airborne radiation.

Although actual cost reductions will vary according to specific situations, a project with reductions in these areas could achieve significant cost advantages. The main disadvantages are often the limited recovery rates that can affect marketing strategy and project life, and sometimes uncertain restoration costs.

TABLE 5

MAJOR PILOT AND COMMERCIAL SOLUTION MINING PROJECTS IN THE USA

Project/Operator	State	Originally Started	Shut Down	Status
Shirley Basin (Utah International)	Wyoming	1961	1969	closed
Duderstadt Pilot (Cities Service)	Texas	1969	1971	closed
Highland (Exxon, Everest/Wold)	Wyoming	1972	—	operating/restoration
Bruni (Wyoming Minerals)	Texas	1975	1983	restoration
Clay West (US Steel/NMU)	Texas	1975	—	restoration
Nine Mile Lake Pilot (Rocky Mtn. Energy)	Wyoming	1975	1980	closed
Palangana (Union Carbide, Chevron)	Texas	1975	1977	restoration
Burns (US Steel/NMU)	Texas	1976	—	restoration
Lamprecht (Wyoming Minerals, IEC)	Texas	1977	1981	standby
O'Hern (Mobil)	Texas	1977	—	restoration
Pawnee (IEC)	Texas	1977	1979	closed/restoration
Brelum (Mobil)	Texas	1978	1982	closed
NuBeth Pilot (Nuclear Dynamics)	Wyoming	1978	1979	closed
Red Desert Pilot (Union Oil)	Wyoming	1978	1978	closed
Reno Creek Pilot (Rocky Mtn. Energy)	Wyoming	1978	1980	closed
Irigaray (W. Minerals, Westinghouse)	Wyoming	1978	1979	standby
Zamzow (IEC)	Texas	1978	1986	restoration
Bison Basin Pilot (OPI)	Wyoming	1979	1982	closed

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TABLE 5 (continued)

MAJOR PILOT AND COMMERCIAL SOLUTION MINING PROJECTS IN THE USA

Project/Operator	State	Originally Started	Shut Down	Status
Crown Point Pilot (Mobil)	New Mexico	1979	1980	closed
El Mesquite (Mobil)	Texas	1979	—	operating/restoration
Hobson (Everest Minerals)	Texas	1979	1981	standby
Longoria (Uranium Resources Inc.)	Texas	1979	1982	restoration
Benavides (Uranium Resources Inc.)	Texas	1980	1984	restoration
Collins Draw Pilot (Cleveland Cliffs)	Wyoming	1980	1982	closed
Leuenberger Pilot (Teton)	Wyoming	1980	1981	closed
Nell (Mobil)	Texas	1980	1981	closed
Bill Smith (Sequoyah)	Wyoming	1981	—	restoration
Las Palmas (Everest Minerals)	Texas	1981	1984	standby
McBryde (Caithness)	Texas	1981	1984	standby/restoration
West Cole (Tenneco)	Texas	1981	1984	standby
N. Platte Pilot (Uranium Resources Inc.)	Wyoming	1982	1982	closed
Trevino (Conoco)	Texas	1982	1984	restoration
Mt. Lucas (Everest)	Texas	1983	—	operating
Highland (Everest/Wold)	Wyoming	1984	—	pilot
Crow Butte (Ferret Exploration)	Nebraska	1986	—	pilot
Christensen Ranch (Malapai Resources)	Wyoming	1986	—	pilot
Tex-1 (Everest)	Texas	1986	—	pilot
Kingsville Dome (URI)	Texas	—	—	permitted

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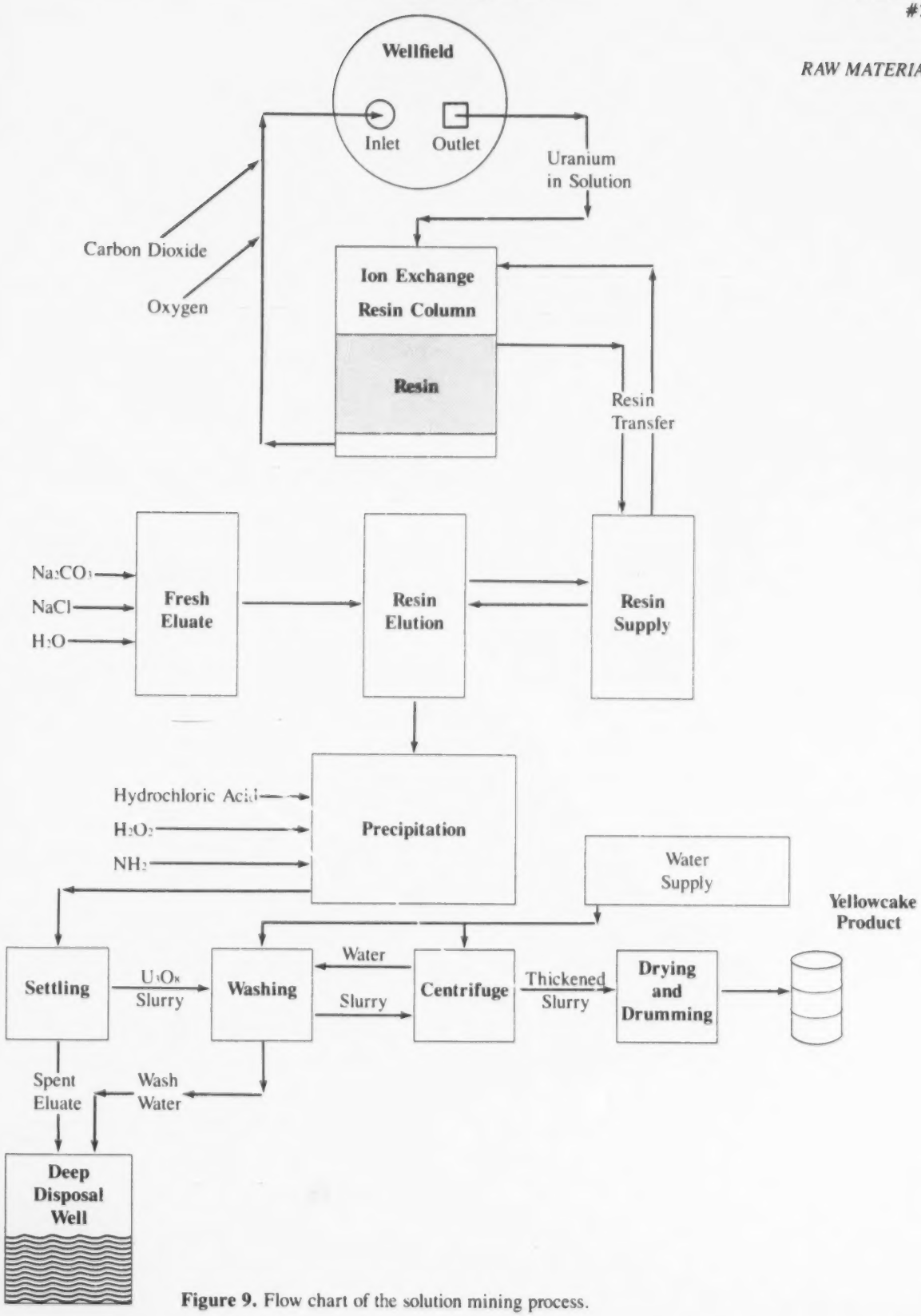

Figure 9. Flow chart of the solution mining process.

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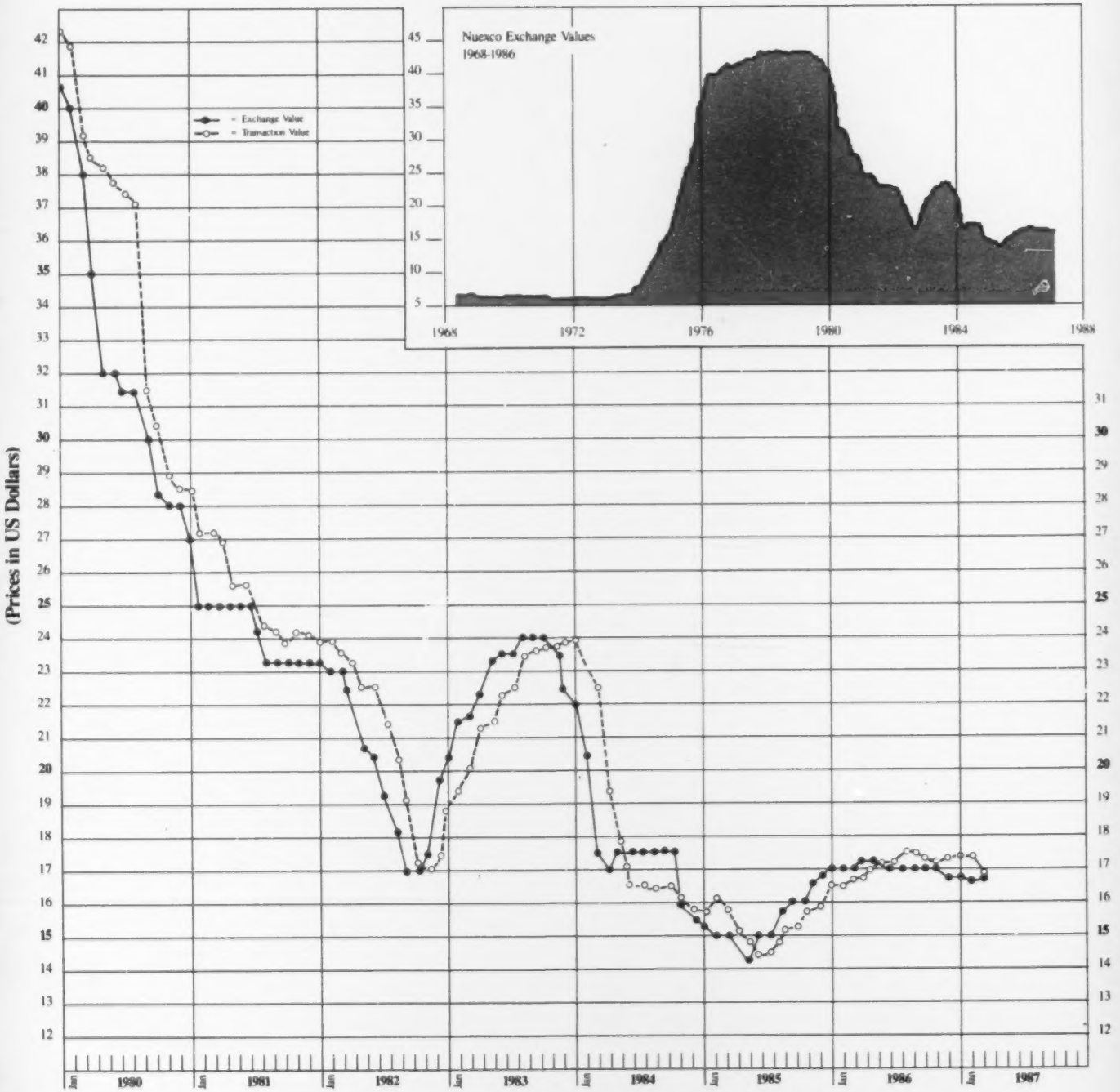
HISTORICAL MARKET DATA



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HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	**16.75**										

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	**16.90**										

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HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	**1.80**										

HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	**48.00**										

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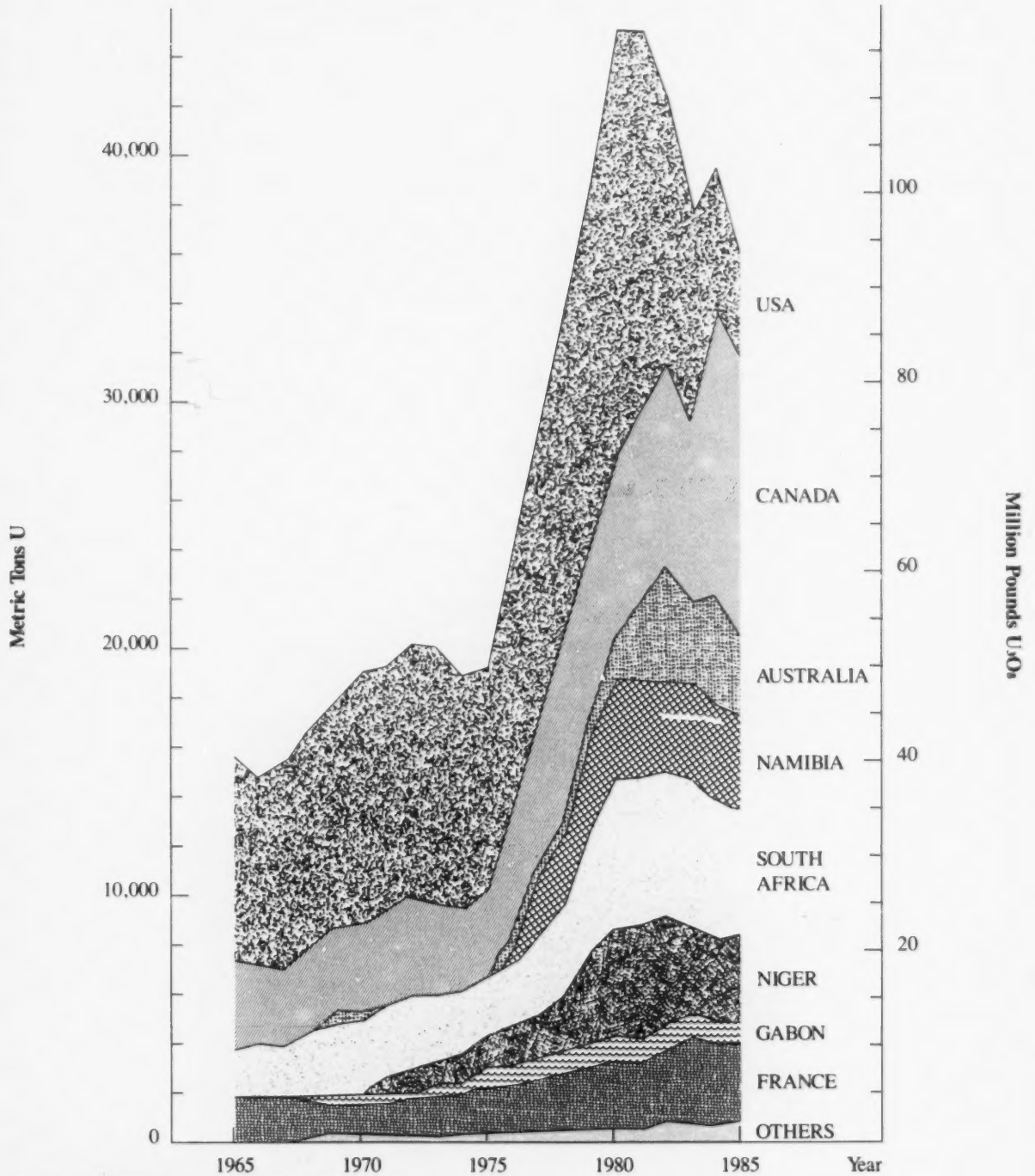
HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1]WOCA = World Outside of Centrally-planned Economic Areas.

[2]1985 production data are preliminary.

[3]A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

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HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2]Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

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VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4]Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

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GOVERNMENT STATISTICS

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[2] (1976 = 100)
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3 4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7	202.5
Oct 1985	108.4	202.4
Nov 1985	109.4	209.9
Dec 1985	110.0	210.0
Jan 1986	109.6	210.0
Feb 1986	108.7	210.0
Mar 1986	99.5	210.5
Apr 1986	94.3	210.5
May 1986	93.5	210.5
Jun 1986	95.7	210.5
Jul 1986	98.1	215.3R
Aug 1986	98.2	215.3R
Sep 1986	105.6	215.3
Oct 1986	106.2R	215.4
Nov 1986	105.2	215.6
Dec 1986	—	215.6

P = Preliminary R = Revised since last month

[1]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4]Annual averages prior to 1979 reflect index base no longer in use.

[5]Monthly data for 1979-82 appear on page 35 of Report 184.

[6]Annual averages are for financial year ending June 30.

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GOVERNMENT STATISTICS

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4R	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9R	19.97	16.81R	16.11R	13.30R	11.59R	12.94R
Nov 1986	119.8	20.11P	17.04P	16.24P	13.47P	11.58P	12.93P
Dec 1986	119.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6]Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7]Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8]Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

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GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929R	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772R	511,363R
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	755,480	531,045
Dec	1986	85.38	189.9	244.9	232.1	—	—

P = Preliminary R = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3]Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4]The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5]Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6]Bulletin of Statistics, Department of Statistics, Pretoria.

[7]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9]Monthly data for 1979-82 appear on page 39 of Report 184.

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UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7R	297.5R	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.3	298.3	330.5	—	12.51R	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57R	13.27R	12.15R	9.75R
Dec 1986	309.3	298.1	331.1	115.3	12.61P	13.17P	12.19P	9.84P
Jan 1987	313.6	300.9	—	—	12.65P	—	12.16P	9.81P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4]The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7]Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

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